THE

Compleat Gunner,

IN

THREE PARTS.

PART I.

Shewing the Art of Founding and Casting Pieces of Ordnance, with the composition of Metal thereunto necessary.

The Composition and Matters of Gunpowders, the Several Sorts, Colours, and Operation.

PART II.

Discovers the necessary Instruments, and variety of Instructions to the compleating of a Gunner, with a Table of Squares and Cubes serving for the Resolution of Questions of Gunnery and other Arts.

AS ALSO

The way of taking Heights, Distances and Profundities, either with or without Instruments.

PART III.

Shews the Nature of Fire-works, the manner of Composing many that are Excellent and Useful both for Sea and Land, for the defence of our selves as well as the offence of our Enemies.

Translated out of *Casimir*, *Diego*, *Uffano*, *Hexam*, and other Authors.

To which is added the Doctrine of Projects applyed to Gunnery by those late famous Authors *Galilæus* and *Torricellio*, now rendred into English.

TOGETHER WITH

Some Excellent Observations out of *Mersennus* and other famous Authors.

LONDON,
Printed for *Rob. Pawlet*, *Tho. Passinger*, and *Benj. Hurlock*. 1672.

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TO THE

READER.

Courteous Reader,

AMong *Arts and Sciences Mathematical Gunnery will not deſerve the leaſt reſpect which has been practiſed for many years (as you may read in the firſt Chapter of this Book where we treat of its Original) and from time to time Neceſſity and Art together have produced many new Invention: ſo that ſome may judge it almoſt impoſſible to add more unto this Art; and are ready to ſay of this as of other Studies,* Nil dictum quod non dictum prius. *But we have not only indeavoured the inquiſition into the moſt knowing Profeſſors of theſe Arts both* German, Italian, Frenchmen, Netherlander, *&c. from whence we have drawn the more Excellent and uſeful parts which were never before in our* Engliſh *Tongue; but may boldly adventure to call ſome things in it new: And finding the great Occaſion which theſe preſent times do require in the knowledge of theſe things made me the readier to compoſe this Work, adjudging it a very great injury to our Country-men to be deprived of the knowledge of ſuch things which are of ſo great importance in this very juncture of time. I did therefore incourage my ſelf in this Work, hoping my endeavours in the ſame will ſhew my willingneſs to ſerve my Countrey-men: And as it is the part*

of wiſe men not to cenſure any thing, without a good conſideration and a perfect knowledge of the ſubject upon which they ought to ground their judgment: So alſo I hope you will not blame my Indeavours, when you have judiciouſly examined the ſame. I have divided it into three Parts, endeavouring that it might be imperfect in nothing that is neceſſary to this Art, or uſeful for a Gunner to know. I will aſſure you that I have no other end in publiſhing this Treatiſe, than what I have mentioned before.

I ſhall only crave your pardon for the faults that may be committed in the Printing, as being not there preſent at the Correction of any part of it, my occaſions calling me other wayes: yet I hope their care was ſo much that the faults are not material, or at moſt not ſo much but your Courteſie may ſupply that defect. So I recommend this Work to your good reception, and bid you farewell.

W. T.

THE

THE Compleat Gunner.

CHAP. I.

Treating of the Earth neceſſary in making of Molds for the Caſting of Pieces of Ordnance, With the manner of Caſting, &c.

WE will not diſpute of the firſt Invention of Guns, that is, whether it came from *Archimedes*, as the *Italians* do report, or from an *Engliſhman*, or from a *Monk*, for this knowledge matters not much to the Art, nor is it of any profitable ſignification to the Artiſt; eſpecially conſidering, that Authors do not really conſent in this thing. Our intent is therefore not to trouble the ingenious Students with vain uncertain repetitions, but to compoſe a compleat Piece of Gunnery, and therein to diſcourſe from the beginning to the end, all that is neceſſary to be known or learned (after the knowledge of common Arithmetick) by one that intends to be a perfect Proficient in the ſaid Art. We do ſuppoſe it therefore neceſſary for a Maſter Gunner to know firſt the making of Molds and caſting of Pieces. Therefore I ſhall firſt begin to diſcourſe of the property and Nature of the Earth fit for caſting, or making Molds; for this is of great moment, conſidering that many, or indeed moſt Earths are not for this purpoſe; for the Earth fit for the caſting of Pieces of Ordnance muſt be ſuch as will not be melted or fuſe, although it be put into a very great fire, but muſt remain firm and hard: and theſe Earths are generally of a Reddiſh, or Iron-like colour, which is well known to many Potters, eſpecially ſuch as make *Chymical* Veſſels. The Earth being obtained, it muſt be ſifted and caſt up after the uſual manner, as men do in the making of Morter; then let it be moiſtned with an Alchalated Water (eſpecially ſuch as is made of Niter) for that purpoſe, and make it like paſte; then, as is uſual, let it be beaten up ſtrongly with an Iron Bar; the more 'tis beaten the better it is: in the beating add one ſixt part of Horſe dung, and a proportionable part of Flox or Hair, and let it again be well beaten and incorporated, alwayes keeping a Moity of this Earth without Hair or Flox, which is for Ground-work; and theſe Compoſitions or Earth thus incorporated, you muſt reſerve for the making your Molds for Pieces of Ordnance, according to the Rules preſcribed in the next Chapter.

CHAP. II.

Of making Molds, and Caſting Pieces of Ordnance, with the Mixture of Metals, and allowance of Powder for proof.

AS a Maſter Builder when he intends the Building a Ship, makes firſt a Mold or Moddel of the ſame; ſo the Maſter Gunner, or he that takes in hand the buſineſs of Caſting Guns, muſt have a form or Model of his Piece intended made of wood, or ſuch other matter he may think moſt convenient, which then being brought to the Founder with an intent to be Caſt, muſt firſt be ſmeered all over with Palm Oyle, or inſtead of that, our Lard or Hogs-greaſe, then firſt cover it over with the ſaid earth thinly, and let it dry leiſurely, then lay on more, encreaſing it to ſuch a thickneſs, as you may judge convenient for your purpoſe; and it muſt be ſo made that it may be taken into ſeveral parts, ſo that the pattern may be taken out, and the Mold again exactly cloſed, and the outſide ſtrengthned with Iron plates as long as the Chace of the Piece is, and hooped together with Iron hoops to knock on and off. Then muſt there be made (with the ſame earth upon a ſquare Bar of Iron, bound round with a Cord that the clay may ſtick well) a form exactly round, of the faſhion of the concave of your Piece (whether you intend it a Cylender or a Chamber-board Piece) proportioned both in length and diameter, and it muſt be placed exactly in the middle of the concave; and when all is well joyned together, be ſure it be well polliſhed and ſmoothed, that the Metal may run the better, and be the clearer from flaws, holes, or clefts.

In the beginning of your work take care that your Mold be exactly proportionable as to heighth and ſubſtantialneſs of Metal, according to the nature of the Piece you intend. That is, the Canon double-fortified muſt be ſo caſt that the Diameter at Muzzle be but $\frac{1}{10}$ of the Diameter at Britch. The leſſer Cannon at Britch to be $\frac{3}{4}$ ſo big as the greater Cannon $\frac{3}{11}$ at Trunions, and $\frac{1}{10}$ at Muzzle, whereas ordinary fortified Cannons have at the Touch-hole $\frac{7}{8}$ at the Trunions $\frac{1}{8}$ and at the Muzzle $\frac{2}{3}$, all leſſer Pieces in that kind have $\frac{18}{19}$ at the Touch-hole $\frac{11}{12}$ at Trunions, and $\frac{9}{10}$ at Muzzle; and the ordinary fortified Culverins are fortified every way like the double fortified Cannon, and the leſſer Culverin like the ordinary fortified Cannon in all reſpects.

Great care muſt be taken in the Caſting of Pieces of Ordnance, that they be equal every way in proportion of Metals, that is, that the Cylender be in the very middle of the Metal, that it may be truely bored, otherwiſe your Piece will fail the Artiſt that ſhall uſe it, until the error be known.

In the next place let the Trunions be exactly placed in a Diagonal line with the Axis of the Piece; and they may be placed in their proper diſtance from the Muzzle and Britch, if you obſerve theſe Rules. Take the length of the bore of the Piece from Muzzle to Britch, divide that meaſure by ſeven, and multiply that ſum that cometh of the Quotient by three, the Product will ſhew you how many inches the Trunions muſt ſtand from the loweſt part of the concavity of the Piece.

And farther note, that the Trunions ought to be placed ſo, as $\frac{1}{3}$ of the Circumference of the Piece, may be ſeen in that place where the Trunions are ſet.

When all additional Patterns, as Britch, *&c.* be made and Luted in their proper place, all things at pleaſure being neatly added to the pattern, let the Mold then be fixt or placed ſo as is moſt convenient for the pouring in the Metal; ſo when

the

the Metal is caſt, the perfect impreſſion will be made upon the ſuperficial part of the Piece, and the Cylender will keep the bore propoſed according to what you have preſcribed, the length of the Piece and its Diameter of the bore may be found by the following Table in the next Chapter. For the Metals generally uſed for thoſe Guns, generally called braſs Guns, they are mixtures, and many times varied as experience will give leave. Some of the chieſeſt do approve of this mixture, that is, to every hundred Weight of Copper 24 pounds of Tin, and 6 pounds of Lattin. Others to 100*l.* of Copper, add 8 *l.* of Tin, and 10 *l.* of Lattin. Others to ever 100*l.* add 20 *l.* of Bell-Metal, which is 25 *l.* of Lead and Tin to every 100 *l.* of of Copper. Some add Tin, Lead, Copper, and *Lapis Calaminaris* together; ſo every one follows ſuch wayes of Compoſition as doth moſt pleaſe his own Experience. The Copper and other better Metals being once melted, the Tin and Lead is added for the better and quicker fuſion; and the higher the Metal is in fuſion, the more ſolid and compact your Metal will run and ſettle. The Lattin doth incorporate and cauſe the Piece to be of a good colour, and the Tin doth ſtrengthen and bind the other matters together. Now a Piece of Ordnance being Caſt, before it comes to Service, it muſt be put to tryal; for which purpoſe there is uſed for proof, according to the weight of the ſhot, about two thirds, or four fifths of that weight in Powder, and for ſmaller Pieces more.

CHAP. III.

The Names of the principal Pieces of Ordnance uſed in England, their Weight, Length, Diameter of the Bore, Height and Weight of the Shot, allowance of Powder.

THe greateſt in uſe is the Cannon Royal, which is in weight of Metal about 8000*l.* in length about 12 foot, carries a Shot of 7½ inch. Diameter, and its weight is 58*l.* of Iron, its bore is 8 inches, requireth for her charge in Powder, 32*l.* 8 *z.*

Demi-Cannon of the greater ſize, called by ſome Cannon of Seven, whoſe weight of Metal is 7000*l.* in length about 12 foot, carrying a Shot of 6¼ inch. Diameter, and its weight of Iron is 42 *l.* 10 *z.* the Diameter at bore is 7 inches, requireth for her charge in Powder 20*l.*

Demi-Cannon great ſize, it's weight of Metal is 6000*l.* in length about 12 foot, carrying a Shot of 6¼ inch. Diameter, and its weight in Iron is 34*l.* the Diameter at bore is 6⅞ inch. requireth for her charge of Cannon Powder 18 *l.*

Demi-Cannon ordinary, its weight of Metal is 5600*l.* in length 11 foot, carrying a Shot of 6⅛ inch. Diameter, its weight in Iron is 32 *l.* the Diameter at bore is 6¼ inch. requireth for her charge in Powder 17½ pounds.

The loweſt *Demi-Cannon*, whoſe weight of Metal is 5400 *l.* being in length ſometime 10 and ſometimes 12 foot, it carries a Shot of 6 inches, the weight of that Shot in Iron is 30*l.* the Diameter of the bore is 6¼ inch. it requireth for charge in Powder 14*l.*

Culverin of the largeſt ſize, weighs about 4800 *l.* being in length 10 or 12. foot, it carries a Shot of 5½ inch. Diameter, the weight of that Shot in Iron is 20*l.* the Diameter of the bore is 6¼ inch, it requireth for charge in Powder 12*l.* 8 *z.*

Ordinary whole *Culverin* weighs about 4500 *l.* being in length about 12 foot, it carries a Shot of 5 inches Diameter, the weight of that Shot of Iron is about 17 *l.* Diameter at bore is $5\frac{1}{4}$ inch. it requireth for charge in Powder 11 *l.* 6 *z.*

Culverin of the leaſt ſize, weighs about 4000 *l.* being in length about 12 foot, it carries a Shot of $4\frac{1}{2}$ inch. Diameter, the weight of that Shot of Iron is 15 *l.* Diameter at bore is 5 inch. charge of Powder is 10 *l.*

Demi-Culverin of the greateſt ſize weighs about 3000 *l.* being in length 10 or 12 foot, carries a Shot of $4\frac{1}{2}$ inch. Diameter, the weight of that Shot of Iron is 12 *l.* 11 *z.* Diameter of the bore $4\frac{3}{4}$ inch. charge of Powder is 8 *l.* 12 *z.*

Demi-Culverin ordinary, weighs about 2700 *l.* being in length 10 or 12 foot, carries a Shot of $4\frac{1}{4}$ inch. Diameter, weight of that Shot of Iron is 10 *l.* 12 *z.* Diameter of the bore $4\frac{1}{2}$ inch. charge of Powder is 7 *l.* 4 *z.*

Demi-Culverin lower than ordinary, weighs about 2000 *l.* being in length 9 or 10 foot, carries a Shot of 4 inches Diameter, weight of that Shot 9 *l.* Diameter of the bore $4\frac{1}{4}$ inch. charge of Powder is 6 *l.* 4 *z.*

Saker of the oldeſt ſort, of 1800 *l.* weight, being in length 9 or 10 foot, carries a Shot of $3\frac{3}{4}$ inch. weight of that Shot 7 *l.* 5 *z.* Diameter at the bore 4 inches, charge of Powder 5 *l.*

Saker ordinary, of 1500 *l.* weight, in length about 9 foot, carries a Shot of $3\frac{1}{2}$ inch. Diameter, weight of that Shot 6 *l.* 0 *z.* Diameter at the bore $3\frac{1}{4}$ inches, charge of Powder 4 *l.*

Saker of the loweſt ſize, of 1400 *l.* weight, in length about 8 foot, carries a Shot of $3\frac{1}{4}$ inch. weight of that Shot 4 *l.* 12 *z.* Diameter at the bore 3 inches and a half, charge of Powder 3 *l.* 6 *z.*

Minion of the largeſt ſize, of 800 or 1000 *l.* length 8 foot, height of the Shot 3 inches, weight of the Shot 3 *l.* 2 *z.* height of the bore 3 inches, and one quarter, the charge of Powder, if of 800 *l.* two pounds and a half, if of 1000 *l.* three pounds and a quarter.

The ordinary *Minion* of 750 *l.* in length 7 foot, height of the Shot $3\frac{1}{8}$ inch. weight of the Shot 3 *l.* 4 *z.* height of the bore 3 inches, charge of Powder $2\frac{1}{2}$ pounds.

Faucons of 750 *l.* length 7 foot, height of the Shot $2\frac{1}{2}$ inch. weight $2\frac{1}{2}$ pounds, height of the bore $2\frac{3}{4}$ inch. charge in Powder $2\frac{1}{2}$ pounds.

Fauconet of 400 *l.* in length 6 foot, height of the Shot $2\frac{1}{8}$ inch. weight 1 *l.* 5 *z.* height of the bore $2\frac{1}{4}$ inch, charge 1 *l.* 4 *z.* of Powder.

Rabnet of 300 *l.* length 5 foot, height of the Shot $1\frac{1}{3}$ inch. weight 8 ounces of Iron, height of the bore $1\frac{1}{2}$ inch. charge of Powder 12 ounces.

Baſe of 200 *l.* length 4 foot, height of Shot $1\frac{1}{3}$ inch, weight 5 ounces, height of the bore $1\frac{1}{4}$ inch. charge of Powder 8 ounces.

There are other Pieces in uſe in our Nation, which are called Baſtard Pieces; of which you ſhall have a particular account in its proper place.

CHAP.

CHAP. IV.

The Names of the Principal parts of a piece of Ordnance.

IT is neceſſary for him that intends to be a Gunner to underſtand, after the knowledg of the Piece in general, to know and learn every part and member of a Piece of Ordnance; for well underſtanding the ſame take theſe Inſtructions following.

All the outſide of the Piece round about is called the ſuperficial part of the ſame, or Surface of the Piece; the Inner part is called the concave Cylinder, and Soul of the Piece.

The full length is called the Chaſe of the Piece; ſo much of the Cylinder or concave of the Piece as contains the powder and Shot is called the Chamber or charged Cylinder, the remaining part to the ſmall end of the Gun is called the vacant Cylinder.

The Spindle ſtanding out, or Ears by which the Piece muſt hang in the Carriage, is called the Trunions; the ſpace between the Trunions, the gravity of the Center.

The Pumel or Button at her Coyl or Britch-end is called the Caſacabel or her Deck, the little hole the Touch-hole, all the metal behind the touch-hole the Breach or Coyl, the greateſt ring at her touch-hole the Baſe Ring, the next ring or circle the reinforced Ring, the next the Trunion Rings, the next before the Trunions is called the Corniſh Ring, the foremoſt next the Muzzle is called the Muzzle Ring, Laſtly, all the rings, Circles, Eminencies, at her Muzzle, and ſo thoſe behind the baſe Ring, are Frizes.

Let the Piece with its ſeveral names be placed by this Chapter. Fig. 1.

CHAP. V.

The Mounting of a Piece of Ordnance in its Carriage.

THe Gunners upon Land-Service, for the conveniency of mounting a piece of Ordnance, that is by any means whatſoever diſmounted, have for their principal Services, a Screw, and a Ghynne, and their appurtenances (which you will find in their proper place) by whoſe help they are able to mount a Piece, and place him in his Carriage, whereby he may be able to perform the work intended. Which to perform artificially, obſerve theſe Rules.

Before you endeavour to mount your Piece, above all things have a great and diligent care that the Ghynne be very firmly ſet, ſo that it may not ſlip any way; but ſo placed, that the Pully or Truckle coming down from the head, fall juſt between the Trunions, or gravity of the Piece, whereof to be aſſured you may let fall down from the head of the Ghynne a Plummet with a Line, or for want of a Plummet any ſtone made faſt to a Line, and ſo moving the Ghynne until the ſaid Plummet fall juſt upon the Center of Gravity, which is between the Ears of the Piece, that the metal may fall near equal, or that an eaſie hand may poize it; and this care muſt be the more, if the Ground whereon the Ghynne ſtands be ſandy or looſe Ground, or the Earth be boggy ſoft, ſo that the feet may fail or ſink in or give way, according to

the greatneſs of the weight. For ſometimes it may be neceſſary to put planks or ſome ſolid thing under the Ghynne and Pins to ſtay them; but this as neceſſity ſhall require.

Now the Ghynne firmly placed and ſetled, the Gunner muſt get up by the Ladder, or ſome Steps, to the head or top of it, having the Rope in his hand, ſhall put it through the uppermoſt truckle of the head, and let it fall down to another man again, that he may catch it, that he may put it through one ſide of the Piece to faſten it into the Ears of the Piece, and ſo having put it through them he may draw it up, until he can give it him that is above, and then put it through the other hole of the Truckle, and give it to him that is under him, who muſt reach it again to him that is above, and ſo faſten it to the head of the Ghynne, giving it ſome turns until it come under the uppermoſt Truckle.

This done, he muſt faſten it with great diligence to the lower Truckle, by putting the Ears as through the Ring which is under the ſaid Truckle; after this begin to Hoyſe your Peice, and in the Hoyſing put a ſpar or ſome ſuch thing into the mouth of the Peice, ſo that thereby it may be governed, and may not ſway from one ſide to the other, which would be dangerous; for if it ſhould ſtrike againſt the Rouler or any one of the feet of the Gynne, it may break all, and ſo ſpoil both the work and the men tending upon it. Therefore I ſay, be ſure that thoſe who ſtand by the Spar be careful in guiding the Piece and keeping it ſteddy and right, until the weight of the Piece is well ſetled, a diligent Eye being had all this while, that neither the feet of the Gynne, nor Rope give way; and be ſure every part of the Rope draw equal, and that there be no Knicks, or that they be not tangled one amongſt another; and for that purpoſe, when they begin to hoyſe the Piece, blows muſt be given upon the Tackling until it be ſet tort, and all bear equal.

But if you ſhould perceive that the Ghynne or any part give way, preſently let your Piece ſink, and underlay and ſettle well the feet of the Ghynne, and that as gently as may be, to the end the Croſs beam or Rouler may not be disjoyned or broken.

Then wind it up carefully and very gently by the help of two men onely, and in ſuch a manner, as when one of the Leavers is brought down, it muſt be held there faſt until the other has got purchaſe, and then muſt this other alſo be brought down; this muſt be reiterated ſo often until it be ſo high that the Carriage may be placed under it, ſo that the Trunions may fall into the Sockets, or holes of the Carriage, and then Guide the Piece by the Spar, ſo that it fall eaſily in, and ſo reſt it ſelf in the Carriage, and then let it be well claſped over, and then locked in and faſtned with Forelocks, and ſo you may draw away your Piece where you pleaſe. On board Ships this Ghynne is not of uſe, it being the Boatſwains buſineſs to fix a Tackle that may be able to hoiſt up any Piece into its Carriage, the Slings one part muſt come about the Caſacabel, and the other part about a Billet, ſo made that it may ſit in at the Muzzle, and by ſtrength of hands, or by help of a Windleſs, or Capſtain, it may be hoyſed up ſo that the Carriage may be brought under; ſo that the Gun being Loared, its Trunions may fall in to the holes of the Carriage, which then claſp over with its Iron Claſps; let them be Forelocked, and then with Hand-Tackles be brought where you pleaſe.

See the Figure of the Gynne, and the Field, and Ship-Pieces mounted in the Figure 11.

CHAP

CHAP. VI.

The Way to draw a Piece of Ordnance, with the neceſſary things thereunto belonging both for Land and Sea.

SEeing we have diſcovered the way of Caſting a Piece, and Mounting it in its Carriage, it follows in the next place that in this Chapter we treat of, and ſhew the manner of drawing them from place to place, for Service; where care muſt be taken what the way is that you are to paſs, for if the way be foul, mooriſh, and dirty, there is then required as many more Horſes as in good wayes. That is,

For a whole Cannon of 8000 *l.* you may uſe 15 couple of Horſes, beſides the Tyllar.

For a Demi-Cannon of about 6000*l.* you may uſe 11 couple of Horſes, beſides the Tyllar.

For a Piece of 4000 *l.* weight, you may uſe 8 couple of Horſes, beſides the Tyllar.

For a Field Piece of about 3000 *l.* uſe 6 couple of Horſes, beſides the Tyllar.

For a Saker of 1800 *l.* weight, you may uſe 4 couple of Horſes, beſides the Tyllar.

For a Piece of 1500*l.* weight, you may uſe 3 couple of Horſes, beſides the Tyllar.

For a Faucon, two couple of Horſes, beſides the Tyllar. For a ſmall Drake of about 250 *l.* one Horſe will ſerve: and by the ſame Rule you may find how many Horſes will draw any weight whatſoever.

Many times when Horſes are wanting, men are made uſe of: Upon ſuch occaſions, you muſt divide your men into three drawing files, according to the greatneſs of the Piece; now to the end the Ranks may ſpread, and every man may draw equally alike, faſten to the end of the Carriage a Croſs beam or bar, to which you muſt faſten the drawing Ropes, equally at ſuch diſtance, that one may not impead the other, and let there be beſure one to ſteer the Piece when you come to any winding or turning. If the drawing Ropes be long, 'tis neceſſary to croſs it with Ropes, or ſome light peeces of wood like a Ladder, with two or more croſs peeces; let them be made faſt for the better and more ſteady drawing, and to every there muſt be a Neckline faſtned to the Ropes, and ſo to caſt over every mans Sholders, in manner as is uſed to draw our Weſtern Barges: And you muſt know your proportion of men fit to draw any Piece of Ordnance, and that muſt be regulated according to the goodneſs or badneſs of the way, and ſo more or leſs men, allowing every man to draw about 50, 60, or 80 pounds; for 'tis ſuppoſed a man may draw in ordinary way 50 or 60 pounds but in very good way more than 80 pounds, however 'tis good to have men enough. Let the Spunge, Ladle, *&c.* be made faſt along the Piece to the Ring and Britch end. Sometimes by reaſon of the unevenneſs, ſteepneſs, or other defects of the way, it ſometimes happens, that you may be forc'd to diſmount your Piece, and remount it again; there 'tis neceſſary every Gunner have with him a Ghynne, a Wynche, and all appurtenances neceſſary thereunto. As to the Sea Gunner on board Ship, their occaſions require no more than the Wynch; and their Piece being mounted according to the directions given in the former Chapter, then with one or two Tackles he bring the Piece to the place deſired, where it ought to be well faſtned in its place; for which purpoſe there is thereunto required Tackles and Britchins; and in caſe of foul weather, or that any of the Geer or Tackling be ſuſpected, or by my much tumbling every thing hanging upon the Nail, for fear any Bolts ſhould give way or draw, it is uſual to nail down to the

Deck with Spikes, one Coyne behind each Truck, or at leaſt the after Trucks, which to great Pieces are commonly dead Trucks; ſo that each Piece may have little or no play.

But in caſe any thing ſhould give way in foul weather, then with all ſpeed diſmount the Piece as ſoon as poſſible you can, for fear of further miſchief; for which purpoſe put in his way as he runs from ſide to ſide, Rugs, Pillows, Beds, *&c.* and ſtand ready with Crows and Handſpikes, and with Tackles, to hitch or ketch him cloſe and faſt to any Ring by the Ship ſide, or ſuch other place as beſt preſents. As for the length of the Tackles uſeful, it is uſually known thus; ſee how long the Piece is, and make the Tackles four times as long, and let the Britchin be twice the length of the Piece, and ſomething more. The manner of drawing of Pieces by Man and Horſe, you will ſee in the third Figure.

CHAP. VII.

To Grove or Examine the goodneſs of a Piece of Ordnance, whether it be Flawed, Hony-Combed, Crackt, Chamber-bor'd, &c. With the difference of Common, Legitimate, and Baſtard Pieces.

IT remains neceſſary for this Chapter to treat, or ſhew the way to know, whether a Piece be ſerviceable or no, which is uſually done in the firſt proof by Powder, which we intend not to Write of here, having mentioned it before, and more will be ſaid, when we have ſhewed the compoſition of Powder. That knowledge of a Piece we here intend, is to examine a Piece, bought, or to be taken into Service, whether good or ſerviceable, or out of many Pieces to make choice of the beſt, or ſuch as are freed from holes, flaws, cracks, honycombs, *&c.* And firſt to know if a Piece be free from crack, or have holes through, take a long ſtick, longer than the Piece, made of a Hoop-ſtick or otherwiſe, ſlit it at one end, ſo that you may put a ſhort peece of Candle in it, then light the Candle, and put it into the Piece, and ſo putting it along eaſily, whilſt another laying his Eye cloſe to the Piece, do go along equally with the Candle, until the whole Piece be viewed, and ſo by help of the Light within ſide, the Eye without ſide will perceive whether there be any Flaws, Cracks, *&c.*

This may be done by the reflection of the Sun beams in at the Muzzle of a Piece, by help of a Looking-glaſs, or polliſhed Steel; but many times a Piece may be Flawed or Hony-combed, and cannot be diſcerned through the Piece, and then the beſt way to find them out is thus; make the uſual ſearch with two or three Springs, or in caſe you have them not, bend the Iron point of a Half Pike, then put it into the Piece up to the Britch end or bottom of the Cylinder, turning it round carefully and gradually, as you pluck it out, and if there be any Honey-combs, Cracks or Flawes, the end or bended point of the Half Pike will ſtick or catch at them.

To know whether the Piece be Chamber-bor'd, take a priming Iron that is ſmall, or a piece of Wire, bend it a little at the end, but ſo that it may go down at the Touch-hole, and put it down ſo far as it will go; Then at the Touch-hole cloſe by the Metal of the Piece, make a mark upon the Wire; then gently pluck it up upon one ſide of the Touch-hole, until the bended point ſtop upon the Metal or upper ſide of the Chamber; and then make another mark upon the Wyer, juſt by the Touch-

hole;

hole; then draw out the Wyer, and the diſtance between theſe two marks, is the height of the Chamber or bore of the *Piece* at Britch: take the height of the bore at Muzzle, and if this height at Muzzle agree with that taken at the Britch of the *Piece*, then is the *Piece* full bored; but if they differ, ſo much as the difference is, ſheweth the tapering of the *Piece*, and according to this muſt your former be made for your Cartredges. There is another way to know whether a *Piece* be Chamber-bor'd, or Tapering, by the diſparting of a *Piece*; which way we ſhall ſhew in its proper place, where we treat of diſparting a *Piece* of Ordnance.

Now although we have mentioned in the former Chapters the moſt uſual *Pieces* of Ordnance; yet, as I have ſaid, there are other *Pieces* which are longer, or ſhorter, which are uſed, and are generally called by the name of Baſtard *Pieces*, and they are diſtinguiſhed from the common Legitimate *Pieces* thus; The Legitimate *Pieces* have their due length of Chace, and are proportioned according to the true height of their bore. Baſtard *Pieces* are ſhorter Chaſes, ſuch as the proportion of their bore doth require, and are therefore called Cuts of the ſame nature of the *Piece* they agree with in the bore; as thoſe of Demi-Culverin bore, are called Demi-Culverin Cuts, *&c.* There are alſo *Pieces* called Extraordinary, which are ſuch whoſe Chaces are longer than is uſually for that bore.

Now we have well and duely underſtood how, not only to make, but alſo to examine and prove a *Piece* of Ordnance, in the next place ſhall follow their uſe, ſet down in due order: Wherein firſt 'tis neceſſary for us to treat of the nature of Gun-powder, and its various Compoſitions, with the Materials neceſſary thereunto, and afterward ſhew its uſe.

CHAP. VIII.

Of the Materials uſed in the Compoſition of Gun-powder; and firſt we will treat of the Original of Salt-Peter.

IT is believed by many in theſe latter times, that the Salt-Peter now in uſe, is not the Niter of the Ancients, but a new Invention uſed or found out for the Compoſition of Powder; And that theirs was only a Niter generated by nature, or that Salt that is coagulated of it ſelf, without any humane Artifice, in the Caverns of the Earth, from whence they took it which nevertheleſs they divide into four different Species, to wit, *Armenian*, *African*, *Roman*, and *Egyptian*; and this *Egyptian* holds its name by a certain Region in *Egypt*, in which is found great abundance. *Serapian* delivers to us, that the places from whence they drew their Niter were all one and the ſame, like them where common Salt is formed, in which the water running doth congeal, and condenſeth like a vulgar Stone; from hence came it to be called ſtonified Salt, or Sal-Peter. The ſame Author doth affirm, that Niter was found of divers colours, *viz.* White, Reddiſh, Livid, or Lead-like, and all other colours it was able to take; he ſaith likewiſe that it was found in different forms; for ſome was found full of holes or caverns like a Spunge; others on the contrary were firm, cloſe, ſollid, ſhining, and Diaphanous as Glaſs, which being let fall eaſily will ſplit in thin leaves, and is fryable in beating; and from its various appearances is judged its manifold vertues, in one more powerful than another, which is known by its operation.

From hence we ſee that which is to be found from the teſtimony of the beſt received Authors about the Mineral Niter, and in none is any mention made of Artificial Salt-Peter, or ſuch as we at preſent make uſe of generally, which is called properly *Salt-Peter*, *Sal Nitre*, or *Halinitre*; yet is there very little difference between the Natural that uſeth to be brought to us, and the Artificial, for if we compare the vertues and operations of the one, we ſhall find them in our uſes no way differing, as *Scaliger* teſtifies, ſaying that the ancient Niter is not much different from ours, particularly if we conſider its tenuity and ſubtil part.

There is of the ancient Niter found upon the ſuperficies of old Walls, expoſed to the humidity; but particularly in Cellars and deep Caves, and in covered Vaults; it reſembles perfectly a certain Brine, or white Gelly, or fine Meal, or in more proper ſpeaking, fine Sugar, and is many times white as Snow; and this thus had, the vertues are to be commended, which I my ſelf have taken the pains to collect, in the imitation of many others which I have often ſeen; which if now it be deſired to prepare this Salt according to the method of our Art; It will be congealed into ſmall little long Chriſtals like Iſicles, and it will be like that of the Ancients. But as 'tis impoſſible to find ſo great a quantity, as the continual uſe doth conſume, and neceſſity doth excite to this day for the ſupply of all Wars, which have been great, and in few years conſumed many great and vaſt places of the Univerſe: We are therefore conſtrained to this new ſubject, and are forced even to ſtudy and invent in theſe latter ages a new way to ſupply the want of the former, which being made with much labour and induſtry from the bowels of the Earth, and then purified and waſhed divers times to ſeparate it from its more groſs and Terreſtrial parts, and taken from its firſt crudity, that its may ſhew its likeneſs of its Mother, it is in the end perfectly purified and brought to ſuch a height, that it differs nothing to be of the ſame form and vertue of the ancient Salt-Peter.

Wherefore if I may be admitted to ſpeak my thoughts upon it, I ſhall ſay openly and plainly, leaving none in doubt; the Ancients did indeed find natural growing Niter, which came out of it ſelf at the tops of Rocks, filling the clefts and holes, and there condenſing into ſmall Icicles, it hardens and petrefies. This Niter is natural; but ſince Art is the Imitator of Nature, as 'tis allowed by all, then you may not think it ſtrange, if we can by a little of her aid, and by force of induſtry, attain to the perfection of her productions; nay, (if I may be bold to ſay it) ſuch as ſhall ſurpaſs by far, the more perfect of her works. Do we not daily ſee an infinite of very principal Works brought to light, after a long and painful travel, which is not permitted nature to imitate, although ſhe did imploy at the beſt all her ſecret and full ſtrength to come to perfection. It may from hence herefore be concluded that our Salt made by the Art of Fire, is ſuch as is every way agreeing with that of the Ancients, not any way differing one from the other; eſpecially as to thoſe uſes we intend here. For if according to our method given in the next Chapter, I dare affirm, in all our uſes it will truely imitate the natural, but the more, if it be purified and purged many times: So that at laſt it will come to be more excellent than the Ancient and natural Salt-Peter; which is plainly ſeen in the ordinary way of purifying Common Salt or Sugar, which by Art is ſo purged, that it comes to be far purer and whiter than 'twas before, in its firſt natural dreſs. And this we do ſuppoſe to be a ſufficient argument, or reaſon, for us to judge that our Artificial Salt-Peter is not only as good, but far more excellent than the natural: Which being thus allowed, we will add only a few words of the properties of Niter, and ſo paſs to its Artificial preparation. And firſt of the ſpetting quality and noiſe it makes in the fire, which *Scaliger* would have to be cauſed by its terreſtrity that it holds in it ſelf, which we cannot allow of, but rather judge otherwiſe, for if the Earthy part were the ſubject that made it make ſuch noiſe, then the Earth it ſelf might be adjudged to make a far greater noiſe, ſeeing it is alſo mixed with this Element, and yet we find it cracks not at all, being put in the fire; therefore by conſequence this reaſon is void. Well then, is it of its rarity, which *Ariſtotle* calls *πανσπερμια* and *πανσπερμον*. This cannot paſs for a truth, ſince daily experience doth let us ſee that the Muſhrooms,

or

or Toad-ſtools, and many other things which are of a moſt rare thin nature, yet make no noiſe when put upon burning coals. Neither is the hardneſs that is joyned to theſe more ſubtil parts, the cauſe of the cracking; For we ſee that the Pumice-ſtone will not ſpet nor crack, nor make any noiſe in the fire, although it be of a ſubſtance ſufficiently ſpungy and hard. There muſt therefore be another thing that muſt be the cauſe of this ſpetting, and all the noiſe that is made by Nitre, when it is embraced by the fire. The Divine *Præceptor*, in the 11 Section of his Queſtions ſaith, that the Salt cracks in the fire, becauſe it contains in it much moiſture, which being attenuated by the fire, and rarified in a high degree, converts all into Spirits, and an Airy nature; For in it there is contained more of a Spirit, than watery matter, which being brought to the fire, the two fiery Spirits mutually attract each other, and joyning together, do become Maſter of the leſſer part the Water; for the fire of the Niter being fortified and put into action by the common fire, the Water is conſtrained from its bonds, and can ſtay no longer there, but muſt of a ſuddain depart, and in its way, by the violency of its departure, overthroweth all ſuch obſtacles as come in its way: And in this action the external air being ſtrongly and violently agitated, by their refraction, it breaks with impetuoſity or great violence, and from thence by conſequence follows that hideous and fearful noiſe which commonly and ordinarily happens, in the combuſtion of Salt-Peter, and other Compoſitions mixed with it, whereof Salt-Peter is the greateſt part.

CHAP. IX.

The Way of Preparing Salt-Peter from a Nitrous Earth.

THe Earth and matter of Salt-Peter is found commonly in great abundance, in obſcure ſhadowed places, where no Rain nor any freſh water doth penitrate, nor likewiſe where the Sun by his rayes can communicate his heat; it is likewiſe drawn from Horſe dung under Stables, and from covered places where great and ſmall Cattle are ſhut up; likewiſe in ſuch places as men uſe to piſs in, or Jaqueſes, or the like places; or in places where has been made great Fights, or where has been laid up together many dead Bodies, and earth thrown upon them: For from thence in few years may much Salt-Peter be drawn. I ſhall declare three ſeveral wayes whereby to ground your judgment with more certainty, concerning the goodneſs of the place from whence one would draw the Salt-Peter, which is moſt neceſſary to be known by all Salt-Peter men, or ſuch as intend to mannage theſe Affairs.

The firſt is, that ſuch Earth as you ſuſpect to hold Salt-Peter, be put upon the Tongue, and if it prick a little ſharply, it is a moſt certain ſign you will not looſe your labour in taking it to task; but on the contrary if it be not biting, or a little corroſive, it will not well anſwer your money and labour in preparing of it.

The ſecond way to know a good Nitrous Earth is this: make a hole in the Earth with a ſharp pointed thing, either of Wood or Iron, and in it put a peece of Iron red hot; after having ſtopt the hole, let it ſtand until it be quite cold, then draw it out, and if you find a little after about this Iron ſome Citrine marks, inclining a little after to a whiteneſs, you need not doubt that earth; but further aſſure your ſelf 'tis very good to put to work.

The third way is, throw a little of that Earth upon burning Coals, and if you perceive it make any noiſe, and that it ſpets in the fire, or that clear and ſhining ſparks come from it, you may from thence judge that that Earth holds a forcible matter of that nature.

After you have found a proper Earth to draw Salt-Peter from, and that by ſome of theſe proofs you have teſtimony of its goodneſs and worth, let be taken of it a great quantity, or as much as you pleaſe; let it be carried to a place appointed for this purpoſe, then prepare to burn a good quantity of Wood, either of Oak, Aſh, Elm, Maple, or other ſorts of hard Wood, that you may have Aſhes; then take two parts of theſe Aſhes, one part of quick Lime, mix them well, and put this mixture by it ſelf; for ſuch uſes as I ſhall ſhew you anon.

Take then Veſſels of Wood, or Pipes, or Hogſheads cut in two parts, for they muſt be able to hold a good quantity of Water, make a hole at the bottom about one or two fingers breadth, put into the hole a ſmall wicker thing, or you may whelm over it an Earthen Diſh, after put Ruſhes all over the bottom (not excepting the hole) or in its place clean ſtraw; this Veſſel being thus fitted, diſpoſe of it in this manner; Set it ſo, that under may ſtand a leſſer Veſſel of Wood to receive the Liquor that ſhall diſtil down from the upper Veſſel; after put into the upper Veſſel about the height of a hand of this Salt-Peter Earth, which has been before for ſome time dryed in the Air; upon this Earth put the height of three or four fingers of the mixture made of Aſhes and quick Lime, and then again of the Salt-Peter Earth, after of the Aſhes about the ſame height as before; and continue this faſhion, putting Earth upon Aſhes, and Aſhes upon Earth, until the Veſſel be full within a hands breadth at the top, to hold the Water that is put in; this done put upon it freſh Water as much as ſhall be neceſſary, *viz.* ſo much as muſt ſurmount the Earth two or three fingers breadth, and look that it paſs through all the Earth, and run drop by drop through the hole at bottom of the Veſſel into the Tub ſtanding under, and you ſhall have a Nitrous *Lixivium*, according to the quantity of Water as you poured into the Veſſel; which if you judge is too little, you muſt reiterate the infuſion, and the ſecond time alſo the water paſſing through the Earth will carry with it a ſubſtance; And ſo the third time.

This done, put all the *Lixivium* into a Kettle of a ſufficient bigneſs, and let it be boyled upon the fire very eaſily, and moderately at firſt; after increaſe the fire to the conſumption of the Liquor, or a little more, keeping continually skimming it all the time it boyls. And when 'tis thus conſumed, pour it into wooden Veſſels that are broad, and cover them over with Cloaths, and let them ſtand until the pure part Chriſtalize into white Salt, and the feculent or more terreſtial part ſettle to the bottom. In the mean time continue pouring in of the *Lixivium* again into the Kettle, boyling and skimming it as before; and this do until all your *Lixivium* be boyled up and poured into wooden Veſſels to Chriſtalize.

Then from the wooden Veſſels, inclining them gently, pour all the *Lixivium* (leaving the ſettling at bottom by it ſelf) into your Copper as before, and boyl it up again with a good fire until half be conſumed, or until it begin to thicken, or until by putting a little upon a ſtone or peece of board, it do immediately congeal.

Then take it from the fire, and when 'tis a little cooled, pour it as before into wooden Veſſels or Boles, and put into each about a hand in height; then cover each Veſſel with courſe cloaths, put it into a cool place, and two or three dayes after you will find your Salt-Peter congealed and thruſt together in ſmall Chriſtals, like tranſparent Ice, ſticking to the ſides of the Veſſel, and likewiſe upon ſome ſticks for that purpoſe, provided the rinds being taken off and placed in the wooden Veſſels before the pouring in of the Liquor; get diligently together the Peter, as well that which ſticks to the ſides of the Veſſel, as that to the ſticks, in a Veſſel of wood proper to receive it, and cover it, and keep it dry. The remaining water you muſt boyl up as before, not forgetting to ſeparate it from its reſidence.

Whilſt 'tis boyling, it happens ſometimes that the Liquor may riſe and boyl over the Cauldron; to prevent that danger, have in readineſs other *Lixivium*, made

of

of three parts of Aſhes, and one part of quick Lyme, as we ſpoke before; in which is diſſolved *Roch Allum*, allowing to every hundred weight of *Lixivium*, four pounds of Allum; and when it begins to riſe, pour in a little of this from time to time; And by this means you will ſee that the water that was haſtning to come over, will fall down; and that the common Salt and more terreſtrial part will ſettle to the bottom.

The Earth remaining in the Wooden Tubs from whence the ſalt was drawn, muſt be put in ſome cover'd place made for that purpoſe, where neither Sun, Rain, nor any other water may come; and there it muſt be ſpread all abroad about a foot high: Then you muſt have in readineſs Horſe dung or the Excrements of all ſorts of Beaſts, great and ſmall, and put off this upon the other, about the height of three or four foot; then take all that was skum'd from the *Lixivium* in boyling, and the water that is left and will not ſhoot, and the bottoms that are left in the wooden Veſſel, where the Salt-Peter did ſhoot, and throw them away, as hurtful and uſeleſs, upon the Dunghil; throw likewiſe every day, or as often as you can, the Urine of men, and let it lye two years, and you ſhall have your Earth filled with Salt-Peter as before, with a greater aboundance: You may likewiſe throw upon your Dunghill, the Horns, Claws, and Hoofs of Beaſt, and then from this Earth it will be very eaſie to draw good Salt-Peter by the method we have preſcribed.

CHAP. X.

To Clariſie and Refine Salt-Peter.

TAke as much Salt-Peter as you pleaſe, and being put in a Copper, pour upon it ſo much fair water as will diſſolve it, that is about eight of Water, and three of Salt; and pour upon the ſame of the former *Lixivium*, prepared of Aſhes, Quick-lyme, and Roch Allum; boyl it upon the fire until all the Salt-Peter be diſſolved; that being done, have in readineſs a Veſſel of Wood ſufficiently big, and ſo diſpoſed, that another may ſtand under the ſame: which muſt, before it be ſo ſet, be peirced in the middle, and the hole covered over with an Earthen Diſh: Let the uppermoſt Tub be filled five or ſix inches with fine clean ſand; then let the Tub be covered over with a courſe cloath, and pour through the ſame into your Sand-Tub your diſſolved Salt-Peter, and ſo it will diſtil by little and little into the Veſſel which ſtands under; and ſo paſſing through the Sand, it will be diſcharged of all its ſuperfluities, and will leave the moſt terreſtial part, and ſuch as is uſeleſs, in the Sand, which water again put into the Cauldron, and boyl it up as formerly, until it may be fit to congeal, and in the end pour it into wooden long flat Veſſels as before, and in two or three dayes 'twill be ſhot into Chriſtals as formerly; which if you would have purer, you muſt reiterate this work once more, or you may put upon this Peter, Lyme-water, filter it and boyl it up according to Art, and it will be pure.

Salt-Peter may be purified thus; put your Salt-Peter in a Veſſel of Copper, Iron, or Verniſh't Earth (I like a Crucible beſt) which being put to a ſmall fire, augment it gradually until all the Salt be melted and boyl'd; then take common Sulphur finely pulveriſed, and throw it upon the liquified Salt-Peter, which will quickly take fire and burn, and by the ſame means conſume all the groſs and viſcous humours, with the terreſtrial Salt remaining uſeleſs amongſt the Salt-Peter, before the rectification; beſides you may reiterate this work by putting on freſh Sulphur many times, until ſuch time all the ſtrange humours be quite conſumed; in the end, the Salt-Peter being

well melted and well purified, pour it upon well poliſhed Marble or Plates of Iron, or Copper, or glazed Earth, and let it cool, and you will have a Salt-Peter congealed, almoſt reſembling in colour and hardneſs the true Alabaſter.

CHAP. XI.

How Salt-peter Meal is made without any beating, for the making of Gun-powder.

SAlt-Peter well purified, muſt be put in a Kettle, upon a furnace over a fire, then moderately increaſe the fire with bellows to ſuch a degree of heat, until it begin to ſmoak and evaporate, until the Salt begin to loſe its humidity, and obtain a whiteneſs, and ſo keep continually ſtirring it with a wooden or Iron Ladle, for fear it ſhould return into its priſtine form, and hereby will be taken away all its fatty greaſineſs that may be commixt. This being done, pour ſo much water into the Kettle as will cover the Salt-Peter, and when it ſhall be diſſolved, and it has obtained the conſiſtence of a thick Liquor; then with a wooden ſtick or Ladle keep continually ſtirring it without any intermiſſion, until all its humidity be evaporated, and all be reduced into moſt dry white Meal.

CHAP. XII.

To make Salt-Peter with the flower of Old Walls, or Caves, Cellars, Vaults, &c.

GAther together a good quantity of this Flower, which you may find upon the Surface of Old Walls, which are in moiſt places under the Earth; you may alſo make proviſion with a certain Salt which ſticks to Lyme, or upon ruinated Walls; which Peter, one *Sardi* a *Roman* took notice of, was alwayes well practiſed at *Bruxells* in *Brabant*, as he confeſſeth in his fifth Book of Artillery, *Chap.* 49. Firſt, ſee how much Salt-Peter matter you have; then take one fourth part ſo much of quick Lyme, pour upon it warm water, boyl it well, and clarifie it according to cuſtom, then put your Salt-Peter matter into a Tub with a tap in it, and a little Earthen Diſh before the hole of the tap within, pour into this Tub the Lye, and ſtir it well with a ſtick until all the Salt Peter be diſſolved in the Water; then let it diſtil leiſurely into a Veſſel that ſtands under the tap; and at laſt being all diſſolved and run out, put this water into a Kettle, and boyl it over the fire, until ſo much be conſumed, that the remainder being dropped upon a Tyle-ſtone or Board, do congeal, and be of hardneſs, but not too hard; for if it be very hard, the water is burnt; but if too ſoft, not enough. When 'tis well boyled and ſcummed, take it from the fire, and proceed with it as in the tenth and eleventh Chapters.

CHAP.

CHAP. XIII.

How to examine the goodneſs of Salt-Peter.

PUt upon a Wooden Table, or any clean and ſmooth Board, a little Salt-Peter; then give fire to it with a live coal, and obſerve theſe Rules following, *viz.*

If it make the ſame noiſe in burning as the common Salt doth when it is thrown upon live coals, it is a ſign it holds yet much common Salt.

If it hold a thick and fat ſcum, it is a ſign 'tis fatty and viſcous.

If after the Salt be conſumed, there reſteth yet craſs and filthy matter upon the board, it is an infallible ſign that the Salt contains yet a quantity of earthy matter, and ſo much the more, if you ſee much dregs after the combuſtion of the Salt-Peter is paſt; and therefore the leſs powerful and active.

But by contraries, if it render a cleer long flame divided into many ſtreams, and that the ſuperficies of the board remain neat without any filth; or that it be conſumed ſo that nothing is left, but a white clean aſh, without making much noiſe, or great trembling, you may then conclude that the Salt-Peter is good, and well cleanſed, and in its perfect preparation.

CHAP. XIV.

The true Way to puriſie Salt-Peter, and ſeparating it from all offending and ſuperfluous matter; as common Salt, Vitriol, Allum, and all fatty and viſcous humours.

TAke Two pound of Quick-Lyme, Two pound of common Salt, One pound of Verdigreaſe, One pound of *Roman* Vitriol, One pound of Sal-Armoniack, beat them all together; after put them into an Iron Veſſel, and pour upon them a good quantity of Vinegar, or in default of them, good clear water; and make a *Lixivium*, which you ſhall let rarifie and clarifie of it ſelf, ſtanding the ſpace of three dayes; after put your Salt-Peter in a Kettle, and pour upon the ſame as much of this *Lixivium* as will well cover the Salt-Peter; put it upon a fire ſufficiently moderate at firſt, increaſing it until it boyl to the conſumption of half; take it then away from the fire, and pour it by gentle inclination into a wooden Veſſel, and throw away all the dregs and Salt which remaineth in the bottom of the Kettle: That done, let the Salt-Peter water cool, and continue your preparation as we have given before, where we treated of refining Salt-Peter.

CHAP. XV.

How to clarifie common Sulphur, and to know its goodneſs.

WE experience often, and without contradiction, that not only Salt-Peter is filled with terreſtrial qualities, but Brimſtone alſo, which is not only of a fatty & certain oleganious humour, but likewiſe a noyſome quality which is in the compound, common to one and the other of its matters; from hence (if we deſire to be curious in our work) we judge it may be neceſſary to purifie Sulphur, and to procure to it by power of clarification, a nature moſt ſublime, ſubtile, fiery and volatile. The order and method that ought to be uſed in this, is thus; in Veſſels of Iron or Copper, melt your Sulphur with a very gentle fire over Coals, well lighted, and not flaming; and when it is melted with a Ladle, skim neatly off all that riſeth on the top and ſwimmeth upon the Sulphur; then not long after, let it be taken from the fire, and ſtrained through a double Linnen Cloath into another Veſſel, pouring it through at leiſure; thus all the Oylie matter and craſſy ſubſtance remains in the Cloath; but under in the Veſſel will be a pure Sulphur, ſuch as we have before ſpoken of.

To know the goodneſs of Sulphur you muſt do thus: Preſs it between two Iron plates, that are hot, and if in the running it appear yellow, without any bad odour, and that which remains be of a reddiſh colour, one may believe 'tis natural and excellent; ſo likewiſe 'tis a good ſign, if when 'tis ſet on fire, it do freely burn all away, leaving little or no reſident matter. For if Sulphur be pure and good, we do find that there is ſuch a ſympathy between it and fire, that the fire is deſirous of the Sulphur for its nutriment, and that reciprocally the Sulphur is pleaſed likewiſe to be thus devoured and conſumed by the Element of fire; ſo that if ſome fragment of it be put about ſome pieces of Wood, if this ſhall feel the fire at ſome diſtance, it ſeems as if it did attract it to it ſelf, and doth ſometimes unawares at a diſtance catch or take fire, if great care be not taken.

There is a certain kind of Sulphur which will not burn ſo freely as other Sulphur, nor ſend forth any ill ſcent, but being put upon the fire, melts no otherwiſe than common Wax; and this Sulphur is found abundantly near Mount *Ætna*, as *Carniola* of *Libavius* reports, in his firſt Book of the *Apocap. Hermel.* but this Sulphur is commonly red, as alſo is that which is found in the *Heil des Heim* (as *Agricola* mentions in his firſt Book, *Chap.* 22.) And upon the teſtimony of *John Johnſon, Adm. Nat. Claſ.* 4. *Chap.* 13. Sulphur is found likewiſe of divers other colours, as pale, Yellow, Green, as is many times to be ſeen and found ſticking about Stones and Rocks: So, that a man may, without any great difficulty, take it from thence, and make it into a Maſs.

That which is clear, perfectly yellow, not very hard, nor too much ſhining, is the very beſt. Yet there is another Sulphur which looks greeniſh, and hath never paſt the fire; and this is called *Sulphur Vivum*, and by ſome *Virgin Sulphur*, by reaſon Women and Maids had a cuſtom to compoſe with it a certain *fucus* or Paint, with which they uſed to adorn their faces.

CHAP. XVI.

Of the third principal in Compoſition of Gun-powder, viz. Coal, and its Preparation.

IN the Month of *May* or *June*, when all ſorts of Trees are eaſie to peel, by reaſon in that time there comes out a ſap, and they are fuller of humours than at any other time of the year, Cut then a great quantity of Hazle or Aſh, the length of two or three foot, of the bigneſs of half your fiſt, taking away from them with a Bill all that is Superfluous, then take away the rind likewiſe; and of theſe make little bundles, and make them very dry in a warm Oven; then in a place choſen for that purpoſe, that is plain and even, ſet them upright one by another, and ſet them on fire; and after you ſee the fire well lighted, and that the fire hath reduced them all into burning Coals, cover them cloſely and diligently with watered earth, ſo that it may have no reſpiration, or that no Air may paſs in; then, the flame being thus ſtifled upon the Coals, they will remain pure and whole, without being charged with much Aſhes; then 24 hours after, you may take them away and keep them for to ſerve you in your buſineſs, and put them to ſuch uſes as we ſhall write of hereafter.

But if you have occaſion for a ſmall quantity only, take then of the Arms and Limbs of ſuch Trees aforeſaid, that is of Teil wood, of Juniper, of Aſh, *&c.* Cut them in ſmall pieces, and dry them well; then ſhut them in an Earthen Veſſel, and lute the Cover on the top with Clay; then place Coals round about the Pot, and let it be all covered with Coals, leaving them ſo the ſpace of a good hour, continuing the fire all this while in the ſame degree of heat; at laſt let it cool of it ſelf, and when 'tis cold, open the pot; and take out the Coals for your uſe.

CHAP. XVII.

The Wayes of Compounding or Making Gun-powder.

THe wayes of Compounding of Gun-Powder have been ſo commonly known, that not only ſuch as are converſant in fireworks do underſtand the ſame, but others alſo; ſo that it is made a particular Trade: nay, that which is more ſtrange, the Countrey people in *Polonia* have learned to prepare it with their own hands, without the uſe of any Artificial Engine, or Chymical Veſſel. For I have ſeen many of the People of *Podolie*, and the *Ukrains*, which we call now the *Coſſaques*, who prepare their Powder quite contrary to the common way, or that which is uſed by Fire-Maſters. For they put Sulphur, Salt-Peter, Charcoal, all together in an Earthen Pot, a certain proportion of each; (which proportion one to the other they have learned by experimental practice) upon which they pour fair freſh water, which they boyl upon the fire until all the water is evaporated, and the matter become thick; then

they take it from the fire, and dry it in the Sun, or in ſome warm place, as a Stove, or the like; then they paſs it through a Hair Sieve, and reduce it into ſmall Grains. There are others that take theſe Materials, and grind them upon a ſmooth flat Stone, or a ſmooth Earthen Diſh, and then having moiſtned it, by their Skill they bring it into Grains; which powder brought to this degree of perfection, they ſerve their occaſions with as much utillity and profit, as if it had been made by the hand of one of the moſt knowing or skilful Powder-makers in the world.

It is in my judgment, labour loſt to ſpeak more of theſe ſuperficial wayes; but come to the order and method which is neceſſary and uſually obſerved in the preparing of Gun-Powder: It ſhall likewiſe ſuffice me to propoſe in this Chapter ſome Compoſitions moſt excellent and beſt approved; which are theſe,

Compoſitions for Cannon Powder.		Compoſitions for Muſquet-Powder.		Compoſitions for Piſtol-powder.	
The firſt.		The firſt.		The firſt.	
Salt-Peter	100 *l.*	*Salt-Peter*	100 *l.*	*Salt-Peter*	100 *l.*
Sulphur	25	*Sulphur*	18	*Sulphur*	12
Coals	25	*Coals*	20	*Coals*	15
The Second.		The Second.		The Second.	
Salt-Peter	100 *l.*	*Salt-Peter*	100 *l.*	*Salt-Peter*	100 *l.*
Sulphur	20	*Sulphur*	15	*Sulphur*	10
Coals	24	*Coals*	18	*Coals*	8

You muſt firſt finely powder theſe compoſitions or mixtures, for Cannon or Muſquet Powder, and after moiſten them with fair freſh water or Vinegar, or with *Aquavitæ*; but if you will have your Piſtol Powder ſtronger and more violent, you ought to ſtir it up ſeveral times whilſt it is in the Morter, with this following liquor; that is, a water diſtilled from Rinds of Oranges, Citrons, or Lemons, by an Alymbeck, or any other Chymical Veſſel, then let all be beaten and well brayed 24. hours, and then in the end reduce it into very fine ſmall grains.

A Liquor for this purpoſe may likewiſe be made of twenty parts of *Aquavitæ*, and 12 parts of diſtilled Vinegar made of Whitewine, and four parts of Spirit of Salt-Peter, and two parts of water of Sal-armoniac, and one part of Camphire diſſolved in Brandy-wine, or reduced into Powder with powdered Sulphur, or reduced with Oyl of ſweet Almonds.

To Corn Powder well, you muſt prepare a Sieve with a bottom of thick Parchment, made full of round holes; then moiſten the Powder that muſt be corned with its water, and make it up in Balls as big as Eggs; which put into the Sieve, and with it put a wooden Bowl, and when you have ſo done, ſift the Powder ſo, as the Bowl rouling about the Sieve, may break the Clods of Powder, and make it paſs through thoſe little holes into Corns.

It is obſerved by Fire-Maſters and Gunners, that Powder when it is Corned, is of much greater force and power, than in Meal; from hence 'tis concluded, that powder when 'tis put into a Piece of Ordnance, ought not to be preſſed or beaten home too hard in the Piece; for thereby it will looſe its form of grains, and thereby looſeth a great part of its ſtrength that it had; and is therefore not able to throw out the Bullet with ſo great a violence, as if the Powder had been gently thruſt home to the Britchend.

CHAP.

CHAP. XVIII.

Of the several colours which are to be given to Powder.

KNow first that all the blackness which you see in Gun-powder comes from the Coal; not that this colour is absolutely necessary to be conjoyned to its nature, or that it is absolutely necessary to be given to it for its meliorating or making it more vigorous; this is not so; but by contraryes you may be permitted to give unto it any such colours as you shall think fit, without prejudice or hinderance of the Powder and vertue of it. For if instead of Coal you take rotten dryed wood, or Sawdust well dryed, or white paper moistned and dryed in a Stove and powdered, or indeed any other thing of a combustible nature, or that is well disposed to take fire (such as you read hereunder) and to this you may add a colour according to your fancie and pleasure; and you will infallibly have a Powder that will make the same Effect as the black powder. And for this purpose I shall lay down in this Chapter certain mictions, with which I served my self many times, and therefore known to be experimental truths.

White Powder.

Take Salt-Peter six pounds, Sulphur one pound, of Sawdust of the Elder Tree well dryed and powdered one pound, these mixed according to the directions in the former Chapter, there will be made a Powder of a white colour. Or thus,

Take Salt-Peter ten pounds, of Sulphur one pound, of the woody part when the Hemp is taken away, one pound, *&c.* Or thus,

Salt-Peter six pounds, Sulphur one pound, of Tartar calcin'd until it be brought to a whiteness, and the Salt extracted for use, one Ounce.

Red Powder.

Take of Salt-Peter twelve Parts, of Sulphur two parts, of Amber one part, of Red Sanders two parts, *&c.* Or,

Take Salt-Peter eight pounds, of Sulphur one pound, of dryed powdered Paper boyled up in a Water, wherein is Cinaber or Brazil Wood, and then again dryed, one pound.

Yellow Powder.

Take Salt-Peter eight pounds, Sulphur one pound, Wild or Bastard Saffron boyled in *Aqua Vitæ*, after dryed and powdered, two pounds, *&c.*

Green Powder.

Salt-Peter ten pounds, of Sulphur one pound, dryed Wood or Saw-dust boyled in *Aqua Vitæ* with some Verditer, then dryed and powdered, of this two pounds.

Blew Powder.

Salt-Peter eight pounds, of Sulphur one pound, of the Saw-dust of the Teil Wood boyled in Brandy Wine with Indigo, and after dryed and powdered, one pound.

CHAP. XIX.

Still Powder, or Powder without Noise.

THere are several that do Write many strange things concerning this Still Powder, or Powder, witho ut noise, or as some do give it the name, Deaf Powder, whereof they have treated prolixly; the which I think not convenient to do, by reason I am loath to tire the Reader with any such Discourse, as tends not much to Edification: I shall therefore put down certain mixtures, which I have known to be more excellent and best approved.

First way.

Take Common Powder two pounds, *Venus Borax* one pound; these being well powdered, mingled and incorporated together, must be made up into Corn Powder.

Second way,

Take common Powder two pounds, *Venus Borax* one pound, of *Lapis Calaminaris* half a pound, of Sal-armoniack half a pound; powder and mix them well, and make them up into Grains.

Third way,

Take common Powder six pounds, of Live Moles burnt in an Earthen Pot, of *Venus Borax* half a pound, mix them as before, *&c.*

Fourth way,

Take Salt-Peter six pounds, Sulphur eight pounds and a half, powder of the Second Bark of Elder Tree half a pound, common decripitated Salt two pounds; make Corn Powder of these according to the precedent order, or accustomed method.

To these known things, I shall add here a thing whereof you may make experience if you please; it being only taken from the Books of Authors, without any tryal made by me; which you may also find written in the natural Magick of *John Baptista Porta*, which is in our *English* Tongue, where he saith, that if you add burnt Paper in the Composition of Gun-Powder, or the double quantity of Hay seed well beaten; these will take away a great part of the strength, and will hinder it from making so great flame and noise.

Some do say that the Gall of a Pike doth the same effect, if it be mixed and mingled with the same; but we shall leave the belief of these things to the faith of such Authors as have experimented the same.

There

There are ſome wiſe and knowing men in this Art, attribute the cauſe of this noiſe, or as ſome do expreſs it, this horrible noiſe, produced by a Cannon after the firing, not to the Powder, but to the beating and contuſion of the Air which is inraged, or in a paſſion, by being ſo furiouſly endeavoured to be ſtifled or choaked by a ſtrange and extraordinary movement, of which we have ſpoken more at large in the former Chapter, where we treated of Salt-Peter. Yet in favour of the Sons of Art, we ſhall nevertheleſs give you the opinion of *Scaliger*, taken out of his his fifteenth Book, in his *Exer. Exoter.* againſt *Cardan* of *Subtil. Exer.* 25.

Longe pejus illud cum ſonitus cauſam a bellicis machinis editi, attribuis Sal Petræ; nam tenuiſſimum in pulverem comminutum cavernulas amiſit.

CHAP. XX.

The proof or Tryal of Gun-powder.

IT is accuſtomary for men skilled in theſe Arts, to try Powder three ſeveral wayes; that is, by ſight, by touch, and by fire: And firſt, for the tryal by ſight; it is thus,

If the Powder be too black, it is a manifeſt ſign of too much humidity, or too much coal; now if it contain too much, as you ſuppoſe, rub it upon white Paper; if it black the Paper more than other good Powder uſe to do, it is a ſign there is more coal in it than ought: for ſuch Gun-Powder as is of a fair azure colour, or a little obſcure, ſomthing bordering upon red, is the beſt ſign, and the moſt aſſured teſtimony of good Powder.

Secondly, Gun-Powder its goodneſs is known by the touch, in this manner, cruſh ſome Corns under your fingers ends, and if they eaſily break and return to Meal without reſiſting the touch, or without feeling hard, you may aſſure your ſelf from thence, that your Powder hath in it too much Coal.

If by preſſing it a little hard under your fingers upon a ſmooth hard board, or upon a ſtone, you feel amongſt it ſmall grains harder or more ſollid than the reſt, which do in a manner prick the ends of the fingers, and do not yield to the finger but very difficultly, or hardly, you may infer from hence that the Sulphur is not well incorporated with the Salt-Peter, and by conſequence the Powder is not well and duely prepared.

You may draw infallible proofs or conjectures of the goodneſs of Powder by its burning, if after you have made little heaps of Powder upon a clean and even Table, diſtant one from another about a hands breadth, you then put fire to one of them only; and if it take fire alone, and burn all away without lighting the others, and make a ſmall thundring noiſe, or make a white clear ſmoak, and that it riſe with a quickneſs, ſuddainly, almoſt imperceptible, and if it riſe in the Air like a circle of ſmoak, or like a ſmall Crown; this is an infallible ſign the Powder is good, and perfectly well prepared.

If after the burning of the Powder there remain ſome black marks upon the Table, this then ſignifies that the Powder contains too much Coal, which has not been enough burnt.

If the board looks greaſie, then the Sulphur and Salt-Peter is not enough cleanſed, and by conſequence it retains much of their terreſtrial matter and oyly natures which were naturally conjoyned to their matters. If you find ſmall grains, white and Citrine, it is a teſtimony that the Salt-Peter is not enough cleanſed, and by conſequence it

retains much of its terrestrial matter, and of common Salt, and besides, the Sulphur hath not been well powdered, nor sufficiently incorporated with the two other matters of its Composition.

If two or three Corns of Gun-Powder be laid upon a Paper, distant about a fingers breadth one from the other, and you put fire to them, if the fire be good and strong, they will fire at once, and there will remain no grosness of Brimstone, or of Salt-Peter, nor any thing but a white smoaky colour in the place where they were burnt, nor will the Paper be touched. If small black knots, which will burn downward in the place where proof is made, remain after firing, they do shew that the Gun-powder hath not enough of Peter, and that it is of little force or strength.

Good Gun-Powder will not burn your hand, if it be set on fire there.

Gun-Powder that is very sharp or eager in taste, is not well purified, and will turn moist.

Amongst many sorts of Powder, to know the best, make a little heap of every sort at a distance one from another, observing well when you fire each heap, which of them doth sooneste take fire, for that which sooneste takes fire, smoaks least and cleareste, and riseth quickly up close and round, and leaves little or no sign behind it, is the best Powder.

There are Instruments likewise invented for the tryal or proof of Powder, which the most part of Fire-Masters and Gunners are accustomed to use, which are described at large by other Authors; therefore we shall not here repeat the same; considering likewise, that we have found by experience a great fallacy in the same, for that one and the same Powder, in the same measure and quantities, hath raised the cover to different degrees of height.

CHAP. XXI.

To fortifie weak Powder, and amend that which is spoiled, and bring it to its full strength again; and to preserve good Powder from decaying.

WE call such Gun-Powder weak, which hath much degenerated from its first strength, and the force which it did acquire in its first preparation; as such as hath taken wind, wet, or air; for these do diminish the quantity of Salt-Peter, and actually separate the Sulphur and Coal.

There are two different wayes that these accidents do happen; that is, by being many years made, or lying in a moist place long; for in time the Salt-Peter alters and separates it self, being naturally subject to alter, and return into its first matter; for Salt-Peter in its beginning or original being engendered of water, or of a certain Saline humour, no otherwise than other Salts are produced of their own proper Brines, doth at last, or in a long time, separate it self from the Coal and Sulphur, and so return to a Brine water again, as it was in the original, and so abandons the other two matters that adhered to it, the Sulphur and Coals loosing nothing of their weight, seeing that no humidity that is attracted, can be able to dissolve them; but rather by the contrary, the Coal doth attract greedily, and becomes more ponderous.

If for the reasons aforesaid you desire to repair and restore the strength of Gun-Powder that begins to alter, or that hath quite lost its force, its defects may be amended three several wayes, *&c.* viz.

The

The firſt is thus, make a Lye of two parts of *Aqua vitæ*, and one part of clarified Salt-Peter made into fine Powder, of good Vinegar made of good Wine half a part, of Oyl of Sulphur one eighth part, and as much Camphire diſſolved in Brandy; theſe put together, do make a *Lixivium*, which muſt be ſtrained through a large Strainer, and then with it you may amend your powder that is decayed, by moiſtning it with the ſame, very often, and drying it by the Sun in Wooden Veſſels, and then putting it up in a dry place, free from any humidity or air, and then it will not in a long time again be damnified.

The ſecond way to repair Powder is thus, examine how much your Powder weighed when it was firſt put into the Cask or Barrel, then ſee how much it doth now weigh after 'tis damnified (it being firſt dryed if it chance to be wet) then ſee the difference between theſe two weights, and add ſo much Salt-Peter to your decayed powder, mix it well, and make it up into Corns again, and preſerve it as before.

The third way to reſtore the ſtrength of Gun-Powder, is ſuch as is moſt plain and commonly uſed amongſt the Powder-men; they put upon a Sale-cloath or ſmooth place or board, a portion of damnified Powder, to which they add an equal weight of that which is new made, and then with their hand or wooden Shovel they mingle it well together; then they dry it in the Sun, and put it up into a Barrel again, and keep it in a dry and proper place.

Yet there is another way may be allowed, but this is almoſt the ſame with making new Powder, and it is thus; Take what quantity of decayed Powder you pleaſe, put it into Earthen or Wooden Veſſels, pour upon the ſame three times ſo much hot water, ſtir it well about, and when it begins to be cold, or hath ſtood one hour or two, ſtrain the water away, and to the feces put more water, ſtirring it well about, then let it ſtand and ſettle as before, and ſtrain it from the feces, this do a third time, and you will have drawn out all the Salt-Peter; put theſe waters in a clean Kettle, and boyl it away until ſo much be conſumed, as that a drop dropped upon a Stone or Iron do congeal, then pour it into ſome wooden Veſſel that it may congeal into Salt-Peter; and that water as remains, you muſt boyl up again as before; and if need be, you muſt in the boyling skum what riſeth on the top of the water. Having by this Art obtained the Salt-Peter out of the decayed Gun-Powder, you may according to the proportions given in the Compoſition of Powder, mix it with its remaining Sulphur and Coal, or freſh Sulphur and Coal, which is better; and after 'tis well mixed, Corn it according to the given Rules; then let it be well dryed, and put up into dry Powder Barrels, and let it be conſerved in a dry place from Air or any Moiſture.

Some do mend their Powder in this nature, they moiſten it with Vinegar or fair water, beat it fine, and ſift it and dry it, and to every pound of Powder they put one Ounce of Mealed Salt-Peter; then moiſten and mix them well, ſo that neither may be diſcerned one from the other, but that they be perfectly incorporated, which you may know by cutting the Maſs with a Knife, or breaking it: When it is well compounded, let it be Corned in manner as we have before preſcribed.

If your Compoſition of Powder be made up with *Aqua vitæ*, and ſo made up into great Balls, and well dryed in a Stove, or in the Sun, and put into glazed earthen Pots, and cloſe covered, you may keep it as long as you pleaſe, for age will not decay it.

There ought alwayes a care to be taken by Gunners or Fire-Maſters, or ſuch as have the charge of Gun-powder, to chuſe if they can ſuch places as are dry, and ſtand upon the beſt ground, free from dampneſs of the Air or any water poſſibly coming near. Every Gunner, *&c.* ought to take care that his Barrel be turned upſide down, or any Carthredge ready filled; for if the Powder attract air, the Peter with the moiſture it hath attracted, will in time ſeperate from the other matters, and ſink to the bottom; ſo that the Powder in the upper part will looſe its ſtrength, which is prevented by turning and ſhaking them every fourteen dayes, and airing them at the Sun at convenient times. And as 'tis neceſſary a Gunner ſhould have Carthredges filled for preſent Service, thoſe ought alſo to be turned out and filled again every fourteen dayes more or leſs, as the Gunner in his judgment ſhall allow of.

CHAP. XXII.

Of the property and particular office of every Material in the Compoſition of Gun-powder.

WE ought infallibly to believe that Gun-Powder was not found out caſually, or by fortune; but invented by a true knowledge, and by reaſonable ſpeculation in Natural Philoſophy; conſidering that to this day no man hath oppoſed (notwithſtanding many perſons have made it their endeavour) or could find any other Materials like unto theſe, or of ſuch a nature, which being well united and incorporated together, they are able to produce a fire ſo vigorous, fearful, powerful, and above all, ſo inextinguiſhable that the whole Univerſal matter is conſumed in a moment; which is the more to be believed, ſince we make not much difficulty, particularly in this our Age wherein we live, to add many things to the invention of others, and that (as the Phyſitians ſay) all that had a beginning doth paſs from imperfection to perfection. We deſire therefore it may be permitted (ſince the Inventors have left us nothing in Writing) to propoſe here ſome Obſervations of Speculative truths, drawn from Experiment, which have been made about the ſtrength, nature, effects, and Office of all the matters comprehended in the Compoſition of Gun-Powder, as well of the particulars, as all made up into one body. For I believe, that having inſinuated into a perfect knowledge of the properties, and the affections, as well ſpecificated as general, of all its Ingredients, no body more will fall into thoſe Errors which are too often committed in the Art of *Pyrotechny*.

We muſt therefore know, that Gun-powder was not without reaſon compoſed of theſe three materials, to wit, Salt-Peter, Sulphur, and Coal, but to the end that one might remedy or ſupply the defaults of the others. And this is it which is eaſie to be comprehended in the effect of Sulphur; for this is naturally the very aliment of the fire, ſeeing it joyns with it ſo willingly and freely, and having once taken fire, is moſt difficult to put out, being no otherwiſe rightly than a flaming fire, or, to expreſs it better, a pure flame; and therefore hath an aptitude to enflame the Salt-Peter, by its activity, more than any other kind of fire. But as the Salt-Peter lighted doth go promptly into certain windy exhalations, it hath thereby ſuch a ſtrength in it, that it would by its ventoſity put out the flame which the Sulphur hath conceived, and by conſequence deny it ſelf of that which the Sulphur communicateth to it; hereby you may ſee, if one had made a ſimple compoſition of theſe two things only, that is, of Sulphur and Salt-Peter compounded well together, if fire were then applyed, they would in truth be ſuddenly enflamed, but they would ſoon after go out, that is, the fire will not continue to the Conflagration and Conſumption of the whole matter, the reaſon whereof we have given a little before. It was therefore by good reaſon adjudged, that Coal well dryed and powdered, being adjoyned to theſe two materials in a certain proportion, was an excellent remedy for the ſupplying of this defect, ſeeing that Coal is of ſuch a property and of ſuch a nature, that if it be held to the fire, it will ſoon light and be reduced to a fire without any flame; And from hence it comes to paſs, that the more it is agitated by the Air, or by wind, the more the fire augments, and will not go out, but conſerve it ſelf until the matter that nouriſheth it is totally conſumed, a little aſhes only excepted. From hence it was concluded that a Compoſition made of theſe three Ingredients, ſuch as is our Gunpowder, will conceive fire, and will be conſerved, enflamed and conſumed unto the laſt Atome. For it is moſt certain, that if we approach fire with it, the Sulphur which the fire extreamly loves is ſoon taken with it, and holdeth the ſame and introduceth it, not only

only into the Salt-Peter, but the coal alſo at the ſame moment, without producing any flame. Now this fire (as we have ſaid before) cannot be ſuffocated by wind, but on the contrary is enflamed the more, and takes new ſtrength by the agitation of the Air. And as this Sulphur is a great neighbour of the fire either with or without flame, ſo it cannot hinder it from taking fire; and 'tis the flame of the Brimſtone imbraces the Salt-Peter, and the Coal continues it. And by conſequence theſe three materials joyned together, and well incorporated, and then lighted, produceth a fire, until all its aliment and ſubſtance be univerſally conſumed and annihilated: Yet there muſt care be taken that none of theſe ſubſtances have any accidental defaults, either in humidity or diſproportion, either more or leſs. We will conclude then all that we have ſaid, that the true office of Sulphur in the Powder is to conceive the flame or receive the fire, and having received it, to communicate it to the other matters; and that the Coal hath a particular care to retain and conſume it, and to hinder the fire (after it is once introduced by the Sulphur) from ſuffocating or going out by any windy Exhalation and great violence cauſed by the Salt-Peter; and laſtly, that the moſt notable and particular office of the Salt-Peter is to produce and cauſe a moſt vehement and powerful ventoſity or windy Exhalation. And in this which I have ſaid, lieth all the truth of the ſtrength, power and expulſive motion and activity of the Gun-powder; and by conſequence Salt-Peter alone is the firſt and principal cauſe of all the admirable and aſtoniſhing Effects produced by Gunpowder; and conſequently, the two other materials are alliated with the Salt-Peter for no other end than to make it break forth into fire and wind. For proof of this, if any one will make a Compoſition of Sulphur and Coal only, and with it charge a Piece of Ordnance, he will find that this will not move or thruſt out a Shot of Iron or any other metal; the reaſon of this weakneſs is eaſie to be underſtood by our foregoing diſcourſe, becauſe the violent expulſion depends abſolutely in the Salt-Peter, and in this only expulſive faculty, and not in any of the other matters. Yea I believe that one may prepare Gunpowder without Brimſtone or Coal, rather than without Salt-Peter; or that a man may without much difficulty prepare other matters, that the one may do the office of Sulphur in kindling the matter, and the other that of Coal in Conſerving it and keeping it without flame. But any other thing that hath ſuch hidden natural properties to cauſe ſuch a ventous Exhalation, ſo violent and capable to produce ſuch prodigious Effects, as Salt-Peter, may not be produced.

CHAP. XXIII.

How to prepare Common Match and Extraordinary Match, that is ſuch as will render no Smoak nor bad ſcent.

FIrſt there muſt be made Cords of coarſe hemp, or rather of Tow, about the bigneſs of half your thumb, or a good finger in Diameter; then take the aſhes of Oak, Aſh, Elm, or Maple, three parts, of quick Lyme one part, and make thereof a Lye after the uſual manner; which being done, add to it of the Liquor drawn from Horſe-dung neatly ſtrained and leaſurely exprimed through a ſtrainer, or linnen Cloath, two parts, of Salt-Peter one part, and being all well mix'd, put into a Copper your Match Cords, and pour upon them your *Lixivium*, and make a ſmall fire under the ſame, augmenting it gradually, until it be great, which you muſt keep

boyling two or three dayes continually; not boyling it dry, as ſome of our Writers preſcribe, but ſupplying it continually with freſh *Lixivium*, for fear both Match and Kettle burn for want of Liquor; in the end having taken out the fire, take the Cords out of the Liquor, and wring them hard in your hands, rubbing off the moiſture from them with a peece of Cloath, that comes forth in the wringing, then hang them in the Air or Sun upon long Poles to dry, and when they are well dryed, make them up in bundles, and carry them into a commodious place to keep for uſe.

But to make Match that will never have bad ſcent nor ſmoak, you muſt get a certain quantity of red Sand, or Gravel well waſhed, and purged from all its filth; put it into an Earthen pot that is not varniſhed, then put into the pot upon the Sand, your common Match, or any other made of Cotton, or the like matter, and coyle it in ſuch manner, that there be half a fingers breadth of interval between every coyl of the Match, to the end they may not touch each other, but that the Match in its turning or Coyles have its ſides equally diſtant one from the other, then throw again upon that a good quantity of Sand, and coyl in the Cord again as before: Continue thus your work until your pot be full, then cover the pot with a cover of the ſame earth, and cloſe well the joynts with Lute made of fat Earth that no Air may enter. This being well and ſurely done, put lighted coals round about the pot, and let it ſtand in this poſture ſome time, then take it away and let it ſtand until it be quite cold before you open it; When 'tis perfectly cold, take off the Cover, pour out the Sand, and draw out the match, for 'tis prepared, and will burn as we have ſaid.

CHAP. XXIV.

Of the Square and Cube Roots.

WE have already in the Second Chapter of this Book ſhewn the way of molding and caſting peices of Ordnance; if well underſtood, you cannot be ignorant in the way of Caſting Shot. Therefore to avoyd any thing that might be tedious or unneceſsary to the Students of this art, we will come to the moſt neceſſary things concerning Shot, that is, ſuch as every Gunner ought to know. But becauſe moſt of the propoſitions depend upon the knowledg of the Square and Cube Roots, which many (though otherwiſe knowing in moſt common Arithmetick) do not underſtand, I thought it good therefore to ſhew the Extraction of the Square and Cube Roots after a very eaſie way; with the neceſſary propoſitions in Gunnery, thereunto belonging.

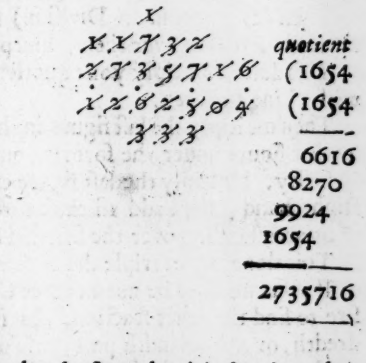
A Table of	1.	2.	3.	4.	5.	6.	7.	8.	9.——Roots.
Squares and	1.	4.	9.	16.	25.	36.	49.	64.	81.——Squares.
Cubes.	1.	8.	27.	64.	125.	216.	343.	512.	729.——Cubes.

The Extraction of the Square Root.

Set down any number of figures as you ſhall think good, as, 273576, then begin at your firſt right hand figure that is at 6, and make a prick under it, and ſo along every other figure as you may ſee here already done; and ſeeing the firſt prick to the left hand falls to be under 2, therefore ſeek in the Table above in the ranck of

Squares

Squares for this number 2, or the neareſt number leſs, which here we find to be 1, and over it we find the Root to be 1, which muſt be placed in the quotient, and likewiſe under the firſt prick to the left hand, then having 1 for a Diviſor, and 1 for the quotient, ſay but the common Rule of Diviſion, 1 times 1 is one, 1 from 2 and there remains 1; which ſent over the 2, then double the quotient and it makes 2, which place between the two firſt pricks to the left hand that is under 7; then ſay how many times 2 in 17, (here you muſt be very cautious not to take too many) which here may be ſix



times, place the 6 in the quotient as before, and under the ſecond prick that is under 3, and divide as before, then double the quotient which is now 16 and it makes 32, place the 2 between the ſecond and third prick, *viz.* under 5, and the 3 before it under the 6, ſo the 32 will ſtand under the 175 which is above; then ſay how many times 3 in 17, which you will find to be 5, place it in the quotient and under the third prick, and divide as before; always ſetting the Remainder over the head of its proper figures; then double the quotient again, which is now 165 and it makes 330, place the 0 between the two pricks as before, and place the figures before it to the left hand, as you ſee above, and the firſt figure to the left will be 3 which ſtands under 13; then ſay how many times 3 in 13, which will be 4, which place in the quotient, and under the fourth or laſt prick, and divide as before; ſo you will find no Remainder, which aſſures the number given to be a ſquare number. The proof of theſe is known by multiplying the ſquare Root found in it ſelf (taking in the remains if any be) and it muſt produce that given number, otherwiſe it is falſe. Note how many pricks you have, and ſo many numbers muſt the quotient conſiſt of.

If the number given be not a true Square, then a fraction will remain, which fraction you may find out the value thereof to a tenth, hundredth, or a thouſandth part, *&c.* Doing thus ſet next to the right hand after the Sum propoſed, two, four, or ſix cyphers, or more (for the more cyphers you put, the leſs is your Error) and every two cyphers will produce a fractional figure more than the Integers belonging to the proper quotient, which are tenths, hundredths, or thouſand parts of a Unite, according to the number of cyphers added; that is, if you add two cyphers, then you find the tenths of a Unite *&c.* But the Square Root being not of ſo much uſe in Gunnery, as the Cube Root, we ſhall proceed no farther to Exemplifie the ſame, ſuppoſing it to be done already in the Treatiſe of Military Diſcipline.

The Extraction of the Cube Root.

Begin at your right hand, (as you did in Extracting the Square Root) and ſet pricks under every fourth figure, that is, leave two figures unprickt, or between the pricks, and ſo proceed to the left, until you have done as here you ſee, 7 5 6 7 8 7 3 2 (the number of pricks ſhew the number of figures that will be in the quotient.

Then ſee by the Table before in this Chapter the neareſt Cube to the numbers ſtanding over the firſt prick to the right hand, which is 75, I ſearch in the Table of Cubes and find the neareſt number to it in the Table of Cubes to be 64, and its Root 4, which muſt be ſet down in the quotient, and likewiſe its Cube 64 under the prick; and if that number doth not amount to ſo much as the number ſtanding over the prick, then ſubſtract it from the ſame, and ſet the Remainder over head.

Then triple the quotient, and that triple you muſt ſet under the next number to the right hand, before that prick where you did laſt end.

Multiply that tripled number by the quotient, and ſet it down under the firſt triple, and that number let be your Diviſor.

Then (as in common Diviſion) muſt you look how many times the Diviſor in the figures is ſtanding over them, and place that in the quotient.

This done, Multiply your quotient by your Diviſor, and ſet it under your Diviſor, with a Line between.

Then multiply the laſt figure in the quotient by it ſelf, and then in the triple, and ſet that figure under the former, one figure more to the right hand.

Laſtly, Multiply the laſt figure cubically, and ſet that Sum alſo one figure to the Right hand; then add all theſe three multiplications together, and ſubſtract it out of figures ſtanding over the firſt and ſecond prick, and the Remainder ſet over them.

This done, again triple the quotient, and proceed exactly as before *&c.*

If your number be not an exact Cube, but ſome numbers remain whereof you deſire to find the exact fraction, that is as near as poſſible may be, *viz.* to a tenth, hundredth, or a thouſandth part *&c.* To find the tenths add three cyphers, the hundreds 6 cyphers, the thouſands nine cyphers, at the Right hand of your figures, according to the directions given in finding the fractional of a ſquare. But theſe Rules being ſomthing tedious to many men, we will for their encouragement and eaſe add a Table of Squares and Cubes whereby any man may find, by inſpection only, the Square and Cube of any number of Inches, and parts of an Inch, to a tenth part, provided your number exceed not 100 inches, which will be found very neceſſary, and ſave much labour, as will appear by the following Examples. But firſt we will preſent you with the Table it ſelf.

A Table

A Table of Squares and Cubes, very useful for the speedy Extracting of Square and Cube Roots, for the Resolution of Questions in Military Affairs: Whether for the Ordering of Battalions, or Gunnery, &c.

R	Aq	Ac
1	1	1
2	4	8
3	9	27
4	16	64
5	25	125
6	36	216
7	49	343
8	64	512
9	81	729
10	100	1000
11	121	1331
12	144	1728
13	169	2197
14	196	2744
15	225	3375
16	256	4096
17	289	4913
18	324	5832
19	361	6859
20	400	8000
21	441	9261
22	484	10648
23	529	12167
24	576	13824
25	625	15625
26	676	17576
27	729	19683
28	784	21952
29	841	24389
30	900	27000
31	961	29791
32	1024	32768
33	1089	35937
34	1156	39304
35	1225	42875
36	1296	46656
37	1369	50653
38	1444	54872
39	1521	59319
40	1600	64000
41	1681	68921
42	1764	74088
43	1849	79507
44	1936	85184
45	2025	91125
46	2116	97336
47	2209	103823
48	2304	110592
49	2401	117649
50	2500	125000
51	2601	132651
52	2704	140608
53	2809	148877
54	2916	157464
55	3025	166375
56	3136	175616
57	3249	185193
58	3364	195112
59	3481	205379
60	3600	216000
61	3721	226981
62	3844	238328
63	3969	250047
64	4096	262144
65	4225	274625
66	4356	287496
67	4489	300763
68	4624	314432
69	4761	328509
70	4900	343000
71	5041	357911
72	5184	373248
73	5329	389017
74	5476	405224
75	5625	421875
76	5776	438976
77	5929	456533
78	6084	474552
79	6241	493039
80	6400	512000
81	6561	531441
82	6724	551368
83	6889	571787
84	7056	592704
85	7225	614125
86	7396	636056
87	7569	658503
88	7744	681472
89	7921	704969
90	8100	729000
91	8281	753571
92	8464	778688
93	8649	804357
94	8836	830584
95	9025	857375
96	9216	884736
97	9409	912673
98	9604	941192
99	9801	979299
100	10000	1000000
101	10201	1030301
102	10404	1061208
103	10609	1092729
104	10816	1124864
105	11025	1157625
106	11236	1191016
107	11449	1225043
108	11664	1259712
109	11881	1295029
110	12100	1331000
111	12321	1367631
112	12544	1404928
113	12769	1442897
114	12996	1481544
115	13225	1520875
116	13456	1560896
117	13689	1601613
118	13924	1643032
119	14161	1685159
120	14400	1728000
121	14641	1771561
122	14884	18158[illegible]
123	15129	1860867
124	15376	1906624
125	15625	1953125
126	15876	2000376
127	16129	2048383
128	16384	2097152
129	16641	2146689
130	16900	2197060
131	17161	2248291
132	17424	2299968

R	Aq	Ac
133	17689	2352637
134	17956	2406104
135	18225	2460375
136	18496	2515456
137	18769	2571353
138	19044	2628027
139	19321	2685619
140	19600	2744000
141	19881	2803221
142	20164	2863288
143	20449	2924207
144	20736	2985984
145	21025	3048625
146	21316	3112136
147	21609	3176523
148	21904	3241792
149	22201	3307949
150	22500	3375000
151	22801	3442951
152	23104	3511808
153	23409	3581577
154	23716	3652264
155	24025	3723875
156	24336	3796416
157	24649	3869893
158	24964	3944312
159	25281	4019679
160	25600	4096000
161	25921	4173281
162	26244	4251528
163	26569	4330747
164	26896	4410944
165	27225	4492125
166	27556	4574296
167	27889	4657463
168	28224	4741632
169	28561	4826809
170	28900	4913000
171	29241	5000211
172	29584	5088448
173	29929	5177717
174	30276	5268024
175	30625	5359375
176	30976	5451776
177	31329	5545233
178	31684	5639752
179	32041	5735339
180	32400	5832000
181	32761	5929741
182	33124	6028568
183	33489	6128487
184	33856	6229504
185	34225	6331625
186	34596	6434856
187	34969	6539203
188	35344	6644672
189	35721	6751269
190	36100	6859000
191	36481	6967871
192	36864	7077888
193	37249	7189057
194	37636	7301384
195	38025	7415875
196	38416	7529536
197	38809	7645373
198	39204	7762392
199	39601	7880599
200	40000	8000000
201	40401	8120601
202	40804	8242408
203	41209	8369421
204	41616	8489664
205	42025	8615125
206	42436	8741816
207	42849	8869743
208	43264	8998912
209	43681	9129329
210	44100	9261000
211	44521	9393931
212	44944	9528128
213	45369	9663597
214	45796	9800344
215	46225	9938375
216	46656	10077696
217	47089	10218313
218	47524	10360232
219	47961	10503459
220	48400	10648000
221	48841	10793861
222	49284	10941048
223	49729	11089567
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237	56169	13312053
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937	877969	822656953
938	879844	825293672
939	881721	827936019
940	883600	830584000
941	885481	833237621
942	887364	835896888

R	Aq	Ac	R	Aq	Ac	R	Aq	Ac
943	889249	838561807	963	927369	893056347	983	966289	949862087
944	891136	841232384	964	929296	895841344	984	968256	952763904
945	893025	843908625	965	931225	898632125	985	970225	955671625
946	894916	846590536	966	933156	901428696	986	972196	958585256
947	896809	849271123	967	935089	904231063	987	974169	961504803
948	898704	851971392	968	937024	907039232	988	976144	964430272
949	900601	854670349	969	938961	909853209	989	978121	967361669
950	902500	857375000	970	940900	912673000	990	980100	970299000
951	904401	860085351	971	942841	915498611	991	982081	973242271
952	906304	862801408	972	944784	918330048	992	984064	976191488
953	908209	865523177	973	946729	921167317	993	986049	979146657
954	910116	868250664	974	948676	924010424	994	988036	982107784
955	912025	870983875	975	950625	926859375	995	990025	985074875
956	913936	873722816	976	952576	929714176	996	992016	988047936
957	915849	876467493	977	954529	932574833	997	994009	991026973
958	917764	879217012	978	956484	935441352	998	996004	994011992
959	919681	881974079	979	958441	938313739	999	998001	997002999
960	921600	884736000	980	960400	941192000	1000	1000000	1000000000
961	923521	887503681	981	962361	944076141			
962	925444	890277128	982	964324	946966168			

CHAP. XXV.

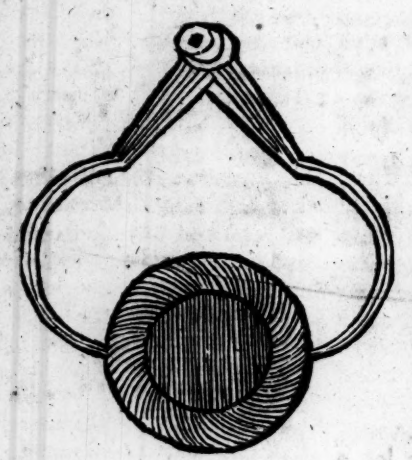
The Use of these Tables in Gunnery.

QUEST. I.

By knowing the Diameter and Weight of any one Shot, to find the Weight of another Shot, being both of one and the same Metal.

THe Shot whose weight we know not, we must have in Diameter likewise, which is found thus, Gird the Shot with a Line, then divide that into twenty two equal parts, and seven of those is the Diameter or the height of the Shot.

But if you have a pair of Callapars by you, the best way is to take the Diameter with them. The fashion and form of taking the Diameter of a Shot, is as here you see in the figure following.



If an Iron Shot of 4 Inches Diameter weigh 9 *l.* what shall a Shot weigh whose Diameter is twice as much, that is, 8 Inches.

Cube each Diameter, then multiply the Cube of the Shot whose weight is required by the Diameter of the given Shot, and that Sum divided by the Cube of the known Diameter, the quotient is the Diameter of the Shot required.

Example.

Inch.	*l.*	*Inch.*		*l.*
If 4 weigh	9	what 8	Answer	72.
4	512	8		
16	18	64		
4	459	8		
64	4608	512		

4608 (72 *l.* The weight of the Shot of 8 Inches Diameter.
448
6

This question may also be performed by the former Table of Cubes, if you search in the Collum of Roots until you find your Diameters in a right Line with the same under

under the word Cube, you will find the Cube anſwerable to the number given, thus; you will find the Cube of 4 to be 64, and of 8 to be 512, and this 512 multiplyed by the weight of the known Bullet, *viz.* 9 *l.* it makes 4608, which divided by 64, gives the weight of the Bullet to be 72 *l.* which was to be known.

QUEST. II.

Knowing the Diameter and weight of one Shot, to find the Diameter of a Shot that weigheth twice as much.

Suppoſe the known Shot was 4 Inches Diameter, and weigh 9 pound, and it were required to find the Diameter of a Shot, whoſe weight is twice as much, that is 18, find the Cube-Root of each Shots weight, then multiply the Diameter of the Shot whoſe weight is known, by the Cube of the Diameter of the Shot whoſe weight is required; and that Sum divided by the Cube of the Diameter of the known Shot and the quotient is the Diameter required. Example. By the former Rule, or by the Table, the Cube of the pounds will be found to be 2,08, and the Cube of 18 will be 2,62, now multiply this laſt number by 4, and it makes 9,48, which divided by 2,08 will give in the quotient 5,03 for the Diameter required.

This queſtion may very eaſily be wrought by the Line of numbers, thus; divide the diſtance between 9 and 18 into three equal parts, and that extent will reach from 4 Inches to 5,03 Inches, the Diameter required.

QUEST. III.

How the former queſtion may be Reſolved Geometrically.

Make a Square of the Diameter of the leſſer Bullet, then draw a Line from Corner to Corner, and this Line thus drawn ſhall be the Diameter of a Shot twice the weight of the other; which if you divide into two equal parts, ſetting one foot of your compaſſes in the middle, you may draw a Circle, and that circumference will repreſent unto you a Bullet twice the weight of the leſſer Diameter.

This work may be proved Arithmetically thus; the Diameter of the leſſer Bullet is 4 Inches, the Square thereof 16, which being doubled is 32; and the ſquare Root of this 32 is 5,65, and ſo much is the Diameter of the greater Bullet, which weighed 18 *l.* There ariſeth here a difference between this way and the former, but this way is the moſt true; not but that both Rules are true in themſelves, but the former depending upon finding the Cube Roots, which cannot be found much more exacter than what I have done, and ſo working by them, and they not being exact, cauſes the difference in the work.

QUEST. IV.

How to find the Diameter for the Weight of any Shot aſſigned.

Suppoſe a Shot of 27 *l.* be 6 Inches Diameter, how many Inches Diameter is a Shot of 64 *l.*

Find the Cube of 64 in the Table, and it will be found to be 4; which multiply by 6, and it makes 24; which divided by 3, the Cube of 27, and it gives 8 Inches for the Diameter of the Shot or Bullet which was required.

QUEST. V.

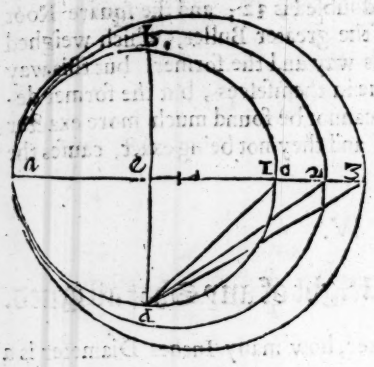
How this Queſtion may Geometrically be reſolved.

Mr. *Gunter* in his firſt Book, Section 4. hath ſhewed how to make a Line of Solids on his Sector; but this Rule ſhews us the proportion of the Diameters in Weight, having a Shot of one pound, two pounds, three pounds weight of Metal, or ſtone, *&c.* For if the given Shot be one pound, divide the diameter of that Shot into 4 equal parts, and 5 ſuch parts will make a Diameter of a Shot of the ſaid Metal, as is propoſed, that ſhall weigh juſt twice as much. And divide the Diameter of a Shot that weighs juſt two pounds into ſeven equal parts, and eight ſuch parts will make the Diameter of a Shot of 3 pounds weight. And Divide the Diameter of a Shot of 3 pounds, into 10 equal parts, and 11 of ſuch parts will give a Shot of 4 pounds weight. And divide a Shot of 4 pounds weight into 13 parts, and 14 ſuch parts will make a Shot of 5 pounds in weight. And divide the Diameter of a Shot of 5 pounds weight, into 16 equal parts, and 17 ſuch parts will make a Diameter of a ſhot that will weigh 6 pounds. And ſo dividing the Diameter of a ſhot 6 pounds weight into 19 equal parts, and 20 ſuch parts will make a Diameter of a ſhot that will weigh 7 pounds. Thus dividing each next Diameter into three equal parts more than the next leſs Diameter was divided into, and with one part added to the Diameter of a ſhot it will weigh juſt one pound more, and ſo may proceed infinitely.

A ſecond way to Perform this work.

Find exactly the Diameter of a ſhot whoſe weight is juſt one pound, then deſcribe a Circle whoſe Diameter ſhall be equal thereunto, and divide it into four equal parts, as *a b c d*, and draw the two Diameters *a c* and *d b* croſſing the Center, and then take the diſtance *d c* in your Compaſſes, and lay it off from *e* to 2, and this will be a ſhot of two pounds weight.

Then take the diſtance *d* 2, in your Compaſſes, and ſet it off from *e* to 3, ſo will that diſtance be the Diameter of a ſhot of three pounds weight; and ſo you may proceed in the ſame manner at your pleaſure; as you may ſee by the projection.



Likewiſe having the Diameter of a Shot of any weight, the double of the Diameter is the Diameter of a Shot that weighs eight times as much. So that if a Shot of four Inches Diameter weigh nine pounds, a Shot of eight inches Diameter will weigh ſeventy two pounds; as you may ſee by this following Table of the weights of Shot.

QUEST.

QUEST. VI.

If a Shot of three Inches and a half weigh six pounds, what will a Shot of seven inches and three quarters weigh.

You may for $3\frac{1}{2}$ put 3, 50. and for $7\frac{3}{4}$ put 7, 75. then you may Cube them the common way; then multiply the second by the third number, and divide by the first, the Quotient gives the content.

You may more easily work it by the Table of Cubes aforegoing; that is, against the Root 3, 50. you will find its Cube to be 42, 875; and against the Root 7, 75. you will find its Cube to be 46, 548. and this multiplyed by 6, and divided by 42, 875, will leave 65, 14. that is 65 pounds and $\frac{14}{100}$ parts of a pound. In this nature may any Fractions be wrought, even as easie as whole Numbers, especially if you reckon your Fractions the Decimal way, or bring them into Decimal Fractions by Reduction.

QUEST. VII.

The Proportions between Bullets of Iron and Bullets of Lead or Stone, that is, by knowing the Weight of an Iron Shot, to find the Weight of a Shot of the same Diameter made of Lead or Stone.

The Proportion between Lead and Iron is as 3 to 2, so that a Shot of two pound of Iron is the same Diameter as a Shot of 3 pounds of Lead.

Example.

If a Shot of Iron of $3\frac{1}{2}$ Inches Diameter weigh 6 pounds, what will a Shot of Lead of the same Diameter?

For $3\frac{1}{2}$ Inches put 3, 5, and say, if 2 give 3, 5, what will 3 give?

35
15
9
105

(1
X 0 5
X X

$52\frac{1}{2}$ *pounds.*

This $52\frac{1}{2}$ pounds is the weight of a Shot of Lead of 3 Inches and a half Diameter.

The proportion between Iron and Stone is as 3 to 8, so that a Shot of 12 pound of stone is as big, or the same in Diameter, as the like Shot of Iron that weighs 32 pounds; but some say the proportion between Marble and Iron is as 15 to 34.

A Bullet of Lead to the like of Marble is in proportion as 4 to 1.

The proportion between Lead and Brass is as 24 is to 19.

The proportion between Iron and Lead, as some say, is as 19 to 28.

The proportion between Iron and Brass is as 16 to 18.

By these Rules we may Calculate a Table very easily, to know if an Iron Shot be wanting, and a Shot of any of the other metals to be had, what height and weight either Shot of Lead Brass or Stone ought to be, to fit any piece of Ordnance; and by the same method we have here Calculated a Table, which doth shew the weight of any Shot of Iron, Lead or Stone; from 2 Inches to 9 Inches.

This is worthy to be observed, that you ought not to have so much Powder to Load a Piece that must discharge a Marble Shot, as an Iron Shot; but the proportion must be abated as the proportions between Stone and Iron doth allow of.

A Table of the Diameter and Weight of all such Shot as are generally used in England, from one to eight Inches Diameter; with the length of every piece fitting to carry such a Shot.

The Names of the *Pieces* of *Ordnance*.	Bore. Diameter of the		Length of the Gun.		Weight of the Gun in pounds.	Ladle. Breadth of the		Ladle. Length of the		Weight of the Powder.		Shot. Diameter of the		The weight of the Shot.		He shoots point blank.
The	Inches.	Parts.	Feet.	Inches.	Pounds.	Inches.	Parts.	Inches.	Parts.	Pounds.	Ounces.	Inches.	Parts.	Pounds.	Ounces.	Paces.
	[8		[8			[8		[8				[8				
A Base.	1	2	4	6	200	2	0	4	0	0	8	1	1	0	5	60
A Rabanet.	1	4	5	6	300	2	4	4	1	0	12	1	3	0	8	70
Fauconets.	2	2	6	0	400	4	0	7	4	1	4	2	2	1	5	90
Faucons.	2	6	7	0	750	4	4	8	2	2	4	2	5	2	8	130
Ordinary Minions.	3	0	7	9	750	5	0	8	4	2	8	2	7	3	4	120
Minion of the largest size.	3	2	8	0	1000	5	0	9	0	3	4	3	0	3	12	125
Saker the lowest sort.	3	4	8	0	1400	6	4	9	6	3	6	3	2	4	12	150
Ordinary Sakers.	3	6	8	0	1500	6	6	10	4	4	0	3	4	6	0	160
Sakers of the oldest sort.	4	0	10	0	1800	7	2	11	0	5	0	3	6	7	5	163
Lowest Demiculvering.	4	2	10	0	2000	8	0	12	0	6	4	4	0	9	0	174
Ordinary Demiculvering.	4	4	10	0	2700	8	0	12	6	7	4	4	2	10	11	175
Elder sort of Demiculvering.	4	6	10	0	3000	8	4	13	4	8	8	4	4	12	11	178
Culverings of the best size.	5	0	10	0	4000	9	0	14	2	10	0	4	6	15	0	180
Ordinary Culvering.	5	2	10	0	4500	9	4	16	0	11	6	5	0	17	5	181
Culvering of the largest size.	5	4	10	0	4800	10	0	16	0	11	8	5	2	20	0	183
Lowest Demicanon.	6	2	11	0	5400	11	4	20	0	14	0	6	0	30	0	156
Ordinary Demicanon.	6	4	12	0	5600	12	0	22	0	17	8	6	4	32	0	162
Demicanon of great size.	6	6	12	0	6000	12	0	22	6	18	0	6	5	36	0	180
Canon Royal, or of	8	0	12		8000	14	6	24	0	32	8	7	4	58	0	185

QUEST. VIII.

How to make a Shot of Lead and Stone together (the Stone being first put into the middle of the Mold, in which the Lead must be afterwards Cast round about the Stone) to be of the like Diameter and Weight as an Iron Shot is of.

It is found by Experience that if you take five parts Lead, and one part of Stone, it will come very near the matter. By these Rules have we Calculated this Table.

It is found by experience, that if you take 5 parts *Lead*, and one part *Stone*, it will come very near the matter, wanting not above 3 Ounces, which is nothing, reſpecting the difference you ſhall find in *Pibble Stones*. Here you have a Table how much *Lead*, and how much *Stone* muſt be together, to make the equal of *Iron Shot*, from 1 *inch*, and to every half in the firſt and ſecond Column to 8 *Inch. Diameter*; the third Column is how much *Lead*, the fourth how much *Stone*, the fifth how much weight both together.

Inches.	Quart.	Lead. Poun.	Ou.	Stone. Poun.	Ou.	Both together. Poun.	Oun.
1		0	1½	0	0½	0	2
1	2	0	6¼	0	1¾	0	8
2		0	14	0	4	1	2
2	2	0	12	0	8	2	4
3		3	2	0	10	3	12
3	2	5	0	1	0	5	0
4		7	7	1	8	8	15
4	2	10	8	2	2	12	10
5		14	7	2	14	17	5
5	2	19	4	3	12	23	0
6		25	0	5	0	30	0
6	2	32	0	6	0	38	0
7		40	0	8	0	48	0
7	2	48	0	10	0	58	0
8		59	0	12	0	71	0

Its uſe is thus; knowing the Diameter of the intended Shot, enter the Table in the firſt and ſecond Columns, and againſt them, in the third and fourth Columns, you have the Weight of Lead and Stone, that will make a Shot of the ſame Diameter with a Shot of Iron, whoſe weight is in the fifth Column.

Example.

An Iron Shot of 2 inches Diameter, will weigh 1 pound, 2 ounces; If I enter this Table with 2 inches, in the firſt Column againſt it, I ſhall find that I muſt have 14 ounces of Lead, and 4 ounces of Stone, and this will make a Shot of 2 inches Diameter equal to the weight of the Shot of Iron.

QUEST. IX.

To find the ſollid Content, and thereby the weight of any Iron Shot.

By the former Table or otherwiſe, find the Cube of the Diameter, which if you multiply by 11, and divide by 21, gives the ſollid Content of that Bullet in inches and parts.

Now to know how many pounds weight any ſuch body doth contain, multiply the ſollid Content by 4, and divide that Sum by 16, it will ſhew how many pounds of Iron that Bullet weigheth, for an inch ſquare of caſt Iron weigheth 4 ounces.

CHAP. XXVI.

Questions about Pieces of Ordnance.

BEfore we come to work what we intend concerning a Piece of Ordnance, it is necessary to understand these Propositions following.

PROP. I.

Having the Diameter of a Circle, to find the superficial Content.

Multiply the square of the Diameter of any Circle by 785 398, and the product that shall come of that Multiplication is the Superficial Content.

PROP. II.

Having the Diameter of any Circle, to find the Circumference thereof.

The common way of proportion is, as 7 to 22, so is the Diameter to the Circumference; but more exactly it is done, if you multiply the Diameter by 3, 14,16, or it may be done thus, as 113 is to 355, so is the Diameter to the Circumference.

PROP. III.

Having the Circumference of a Circle, to find the Superficial Content.

Multiply the Square of the Circumference by 079, 578 will give the Superficial Content, or Multiply the Diameter by half the Circumference, and that Sum is the Superficial Content.

PROP. IV.

Having the Circumference of any Circle, to find the Diameter.

Multiply the Circumference by 318 308, gives the Diameter of that Circle.

PROP. V.

To measure the Frustrum of a Cone or Pyramid, knowing both the Diameters and length of the said Frustrum.

Multiply the Diameters one by the other, and add to them both their Squares, and that Sum divided by 785 39, the one third part of the Remainder is the Content of the Cone.

PROP. VI.

PROP. VI.

By knowing the weight of any one Piece of Ordnance, to find the weight of any other Piece of Ordnance.

If a Saker of 4 inches Diameter weigh 1400*l.* how much will a Cannon of 8 inches Diameter weigh, ſuppoſing they be equally fortified, (otherwiſe this Rule will not hold true) Cube each Diameter, or ſeek in the foregoing Table, and you will find the Cube of 4 to be 64, and of 8 to be 512, then ſay as 64 is to 1400*l.* ſo is 512 to 12919 pounds, and this is the weight of a Cannon that is able to carry a proportionable Charge.

PROP. VII.

To find the ſollid Content of the Concavity, Cylinder, or Soul of a Piece of Ordnance.

By the Rules given in the firſt of theſe Propoſitions, find the Superficial Content or Ayrea of the end of the Cylinder, which multiplyed by the length, will give the ſollid Content.

PROP. VIII.

To find the ſollid Content of the Soul or Concave of a Piece of Ordnance, if it be Tapering, or the Section of a Cone.

The working of this Propoſition is the ſame as in the fifth Propoſition, or you may for brevities ſake, add both the Diameters together, and the half of that may be accounted the mean Diameter, by which you may find the Superficial Content by the firſt Propoſition, which multiplyed by the length, gives the ſollid Content.

PROP. IX.

How by knowing the weight of any one Piece of Ordnance, to find the weight of any other, being of the ſame ſhape.

With your Crallapars take the greateſt thickneſs of the Piece whoſe weight you know, and likewiſe of the Piece whoſe weight you know not; then by the former Table find the Cube of each Diameter, then ſay, as the Cube of the Diameter of the Piece whoſe weight is known, is to the weight of the ſame *P*iece, ſo is the Cube of the Diameter of the *P*iece whoſe weight is unknown, to its weight ſought.

But if the Pieces be not of one and the ſame Metal, after you have found the weight, ſuppoſing it to be the ſame Metal, then you muſt by the Rules given in the 24 Chapter, proportion the weight according to the Metal the Piece is of, whoſe weight you know not, and if the Piece whoſe weight you know, do differ in proportion, as if one be of Iron, the other of Braſs, the proportion is as 16 to 18, *&c.*

PROP. X.

By knowing the weight of any one Piece of Ordnance, to find the weight of any other Piece of Ordnance, although differing in shape or form, knowing the Diameters at Britch, Muzzles, and length of the Pieces.

By the Rules given in the ninth Proposition, find the sollid Content of the *Piece* whose weight you know, supposing it to be a sollid body without a Chamber.

Then take the sollid Content of the Concave part, by Rules given in the seventh *Proposition*, if it be a Cylinder; or by the ninth *Proposition*, if it be Tapering. This latter Content that is of the Concave being deducted from the former Content of the whole *Piece*, gives the sollid Content of the whole Metal in the *Piece*.

Observe the same Rule in finding the sollid Content of the *Piece* whose weight is unknown; Cube both the sollid Contents, and say, as the Cube of the sollid Content of the *Piece* whose weight is known, is to his weight; so the Cube of the sollid Content of the *Piece* whose weight is unknown, is to his weight; but if they be not of one and the same Metal, we must work by proportions, according to the Rules given in the 24th. Chapter.

By these Rules, when Weights and Scales have been wanting, have I found out the weight of several *Pieces* of Ordnance; and if exact account be taken with good judgment and consideration had, of the difference of the Trunions and Britch end, especially if there be any great difference in the *Pieces*, you cannot erre much; for the Rule being demonstratively true, the operation truly done, cannot erre.

PROP. XI.

To find the weight of any Piece of Ordnance, where we have no other Piece of Ordnance, whose weight is known.

Find the sollid Content of the Metal according to the Rules given in the tenth *Proposition*; then multiply that by 4, and dividing that Sum by 16, will give the weight of the *Piece*, supposing it to be Iron; for it is generally allowed that one inch square of Iron will weigh just four ounces.

If the *Piece* whose weight you seek be not of Iron, but of some other Metal; then work by the Rules given in the 24th Chapter, for the difference of the weight of Metals.

CHAP.

CHAP. *XXVI.*

To know the Allowance or Proportion of Powder proper for any Piece of Ordnance.

THe general way is to allow for ſuch Braſs Pieces as are above 4000 *l.* five ounces and a half of powder to a hundred weight of Metal.

But for Culverin of Braſs fortified of above 4000 *l.* about 3 ounces and a half compleat; yet there is uſed alſo generally for the proof of Shot three fourths or four fifths of the weight of the Iron Shot, but for the Service not above half the weight of the ſaid Shot.

For Culverin, the whole weight of their Shot for proof and for action, is two thirds of its weight.

The Saker and Faulcon four fifths, the weight of their Shot; and for leſſer Pieces the whole weight, and one third more for proof; but for action juſt its weight: but when they grow hot, a part muſt be abated according to diſcretion.

You muſt note, if you know how much Powder will Load a Braſs Piece, three quarters ſo much will Load an Iron Piece of Ordnance.

SECT. I.

If Weights and Scales be wanting, and Ladles and the Cartredge not marked, yet to judg a reaſonable Charge for any Piece of Ordnance.

The Allowance that may be made for Cannon is two thirds, the Diameter of the Cylinder for Culverin three Diameters, for the Saker three and a half Diameters, and for leſſer Pieces four Diameters of the Cylinder, which length will alſo ſerve for the Cartredge.

SECT. II.

By the weight of Powder for any one Piece, to find the weight of Powder proper to any other Piece of Ordnance.

To perform this work you muſt find by the foregoing Table the Cube of the Diameter of the bore of the Piece, whoſe allowance of Powder you know; alſo the Cube of the Diameter of the bore of the Piece, whoſe allowance of Powder you deſire to know: Then ſay, as the Cube of the known Piece is the quantity of Powder known, ſo is the Cube of the Diameter of the unknown Piece to the quantity of Powder proper to the unknown Piece.

SECT. III.

Practical Experiments concerning the Allowance of Powder neceſſary to any Piece in time of Service.

It is always neceſſary to take care in time of Service of over-loading a Piece, which Error many run into, only minding the bore of a Piece, and not minding whether the Metal will bear it, and ſo endanger themſelves and other ſtanders by. To avoid ſuch errors obſerve theſe experienced Rules.

To a *Demy-Cannon* fortified of Brass about 4400, or a little more, there is allowed by the Tower 5 ounces and a half of Powder to every hundred weight of Metal; yet in time of Service Gunners do allow but 3 ounces ½ to every hundred weight of Metal, which doth amount to 10 *l.* ½.

Demy-Cannon Drake of Iron about 3800 *l.* is allowed by the Tower 3 ounces and a half of Powder to every hundred weight of Metal, which will be durable in time of Service; but there are Drakes of 4400 *l.* which must be allowed more, according to the proportion of their weight.

Culverin fortified Brass of 4600 *l.* is allowed by the Tower 3 ounces and a half of powder compleat to every hundred weight of Metal, which may be burnt in time of Service with very little abatement.

Culverin Drakes of 4000 *l.* or thereabouts of Iron, for these Pieces may be allowed in time of Service 3 ounces to every hundred weight of metal, but proportionably must be allowed for Pieces of greater or lesser weight.

The 12 Pounders fortified of Brass of 3200 *l.* for Guns of this weight and nature is usually allowed 3 ounces and a half for every hundred weight of Metal.

Demy-Culverin Brass of 3300 *l.* there is allowed by the Tower for Pieces of Ordnance of this nature 3 ounces and a half and somthing more, to every hundred weight of Metal, the which is approved a very sufficient Allowance.

Demy-Culverin Drakes of 2900 *l.* is allowed by most two ounces three quarters to each hundred weight of metal, which will be durable in time of Service.

Saker fortified Brass of 2900 *l.* is allowed 3 ounces and somthing more for every hundred weight of Metal, but there may be a small abatement in time of Service.

CHAP. XXVII.

To know whether a Piece of Ordnance be truly bored or no.

YOu must provide a Pike-staff, about a foot longer than the bore of the Piece, and at the end thereof fasten a Rammer head, that will just fill all the bore to the touch hole, and at the other end of the staff, you must bore a hole big enough to put through a Rod of Iron, which must hang from the same; and at the other end of the Rod must be made a weight about the bigness of a Saker Shot, this is done to make the Pike-staff and Rammer head to lie with the same side upward when they are taken out of the Piece, as they did when they were within the Piece; then you must put your Instrument thus prepared into the Piece, letting the Iron Ball (that is at the end of the Rod, which is put through the hole bored a cross the Pike-staff) hang perpendicular; then take your priming Iron, or some other bodkin, and put it down the touch hole to the Rammer head, making a mark therewith; this done, draw out your Instrument, and lay the same on a long Table, with the Iron Ball hanging off the end perpendicular, as it did when the Instrument was in the Piece; then observe, whether the mark you made upon the Rammer head when it was in the Piece, be just upon the uppermost part of the same, if it be, the bore of the Piece lies neither to the right hand nor to the left; but if you find it any thing to the right or left hand, so much lyeth the bore either to the right or left, and the Piece in Shooting must be ordered and charged accordingly.

But if you would know whether the bore lie more upwards or downwards, then bend a Wire at the very end, so that it being put in at the very touch hole, may ketch at the metal when it is drawn out, then put the Wire down the touch hole till it touch

the

the bottom of the metal in the Chamber, then holding it in that place, make a mark upon the wire just even with the touch hole, after draw up the wire until it ketch at the metal on the top of the Chamber, and holding it there, make a mark as before; the difference between the two marks is the just wideneſs of the Chamber, and the diſtance between the firſt mark and the end of the Wire (having half the Diameter of the Chamber of the Piece ſubſtracted from it) will leave half the Diameter of the Piece, if the Piece be true bored; but if the Piece's number be more than half the Diameter of the Piece, the bore lieth too far from the touch hole, and the upper part of the metal is thickeſt, but if leſſer, the lower part of the metal is thickeſt or hath moſt metal.

CHAP. XXVIII.

Of the neceſſary Inſtruments for a Gunner, with ſeveral other neceſſary things.

A Maſter Gunner intending upon ſervice, ought moſt chiefly to be prepared with theſe Inſtruments, as Calabers, Compaſſes, height board, Sight Rule, Gunners Scale, and a Gunners quadrant; to divide as well into 12 as 90 equal parts, with a Geometrical Square, to make Montures, Levels, heights, Breadths, Diſtances, and Profundities, (of which you ſhall read more in the Second Part;) alſo with a little braſs Level, Scales, Weights, Priming-Irons, Moulds to make Croſs-bar Shot for Muſquets, a Book of Accompts, and an Iron wire or Spring, and a Tranſome to diſpart a Piece of Ordnance; that the Tranſome may go up and down according to the Diameter and thickneſs of the Piece, let the Tranſom be long enough to reach the baſe Ring, from the touch hole. In the next place he ought to be very expert in the knowledg of cutting out, making up, and finiſhing all ſorts of Ladles, Spunges, Rammers, Cartredges, *&c.* For which purpoſe you may have Recourſe to the foregoing Table. And becauſe it may ſometimes happen by reaſon of the ſteepneſs, badneſs and unevenneſs of the way, you may be driven to diſmount and remount your Piece, e're you get up to the top of a Hill; therefore you muſt carry with you a Gynn and a Wynch, with all the appurtenances thereunto belonging; as wind Ropes, an Iron Goats-foot, with a Crow, Pins, Truckles, Pullies to help you at a dead lift.

CHAP. XXIX.

The making of Rammers, Spunges, Ladles, and Cartredges, Formers, Carriages, Wheels, Trucks &c. with the height of Shot fit for any Piece.

FOr the better expedition of this work we have in the former Table ſhewed the length and breadth of each Ladle, always remembring that you cut each Ladle ſomewhat longer, that is, allowing ſo much more as muſt be faſtned to the ſtaff, or ſo much as the ſtaff goes within the Plate.

The Buttons or heads of the Ladles must be near the height of the shot.

For Spunges, the bottoms and heads must be of soft wood, as Birch and Willow, and to be one Diameter and three quarters in length, and three quarters or very little less of the height covered with Sheeps skin, and nayled with Copper nayles, so that together they may fill the hollow of the Piece; Let the bottoms and heads of the Rammers be made of good hard wood, and the height, one Diameter of the Shot, and the length one third of the Diameter of the Shot.

To make Ladles for Chamber bor'd Pieces, open your Compasses to the just Diameter of the Chamber within one eighth part of an Inch, Divide that measure in two equal parts, then set the measure to one of them, and by that distance upon a flat or paper draw a Circle, the Diameter of that Circle is one fourth part shorter than the Diameter of the Chamber; Take three fifths of that Circle for the breadth of the Plate of the Ladle. But for Cannon, the length ought to be twice and two third parts, to hold at twice the just Diameter of the Powder. As for Example,

The Diameter of a Circle drawn for a Cannon whose Chamber bore is 7 Inches, containeth six and three quarters, the circumference whereof is 21 Inches $\frac{6}{7}$, and three fourth parts thereof is 12 $\frac{1}{2}$, and so much ought the Ladle to be in breadth, and in length 18 $\frac{3}{4}$ parts. By this Rule you may make a Ladle for any Taper'd Piece.

Take notice for a general observation, that a Ladle 9 balls in length, and two balls in breadth, will near contain the just weight in Powder, that the Iron Shot for any piece weigheth.

Lastly, for Cartredges, they are generally made of paper Royal or Canvas. Take the height of the bore of your piece without the vent of the Shot, and cut the cloath or paper of 3 such heights, for the Cannon in length 3 Diameters, for the Culverin 4 Diameters, for the Saker and Faulcon *&c.* half of the height of their proper bores, and leaving in the midst at the top or bottome one other such height, to make a bottom for the Cartredge, cutting each side somthing larger for Sewing, glewing, or pasting them together; you must have a great care to augment the goodness of your powder, and likewise the heating of your Piece, and so augment or diminish the quantity of Powder.

Let your Former be made to your Ordnance to the height of your Shot, and a convenient length longer than the Cartredge ought to be, and tallow it over first that the paper may slip off, and then put your paper on your Former. If you make your Cartredge of Canvas, half a Diameter more is allowed for seams, but if you make it of paper, half or three quarters of an Inch over-plus for pasting will serve, being lapt once about the Former, having the bottom fitted upon the end of the Former, which must be hard and close pasted by the lower side of the Cartredge, then let the lower end of the Cartredge be pasted down hard round about the bottom, and let them be well dryed before you fill them, and mark them how high they must be filled.

And if you have no Scales nor weights by you for Cannons, put two Diameters and a half for the height the powder must come, for Culverin 3 Diameters, for Saker 3 and a half Diameters, for lesser Pieces four Diameters of the Cylinder.

For Carriages of Pieces of Ordnance for Land service the Rules are given thus, one and a half the length of the Cylender is the length of the Carriage, and in depth four Diameters of the bore of the Piece at the fore end, in the middle three and a half, and at the end next the ground two and a half, let the thickness be the Diameter of the Shot, the wheels should be one half of the length of the Piece in height, but for Saker and Minion you must exceed the former proportion by one twelfth part, the Faulcon and Faulconet by one sixth part.

The Naves, the Cheeks called Limbres, and wheels, are usually made of Elm, but the Transoms, Axeltrees, Fore-Carriage and Cross beams, are made of Oaken Timber.

For drawing of Guns by men in case horses be wanting, there is usually allowed to every sixty, eighty, or a hundred weight of metal to one man, according to the nature of the ground whereon they are to be drawn.

As for Sea Carriages, they are ſo well known to every Carriage-maker that they need not to be ſpoken of.

As for fitting Shot to each *Piece*, it is the opinion of moſt Gunners, that every Piece of Ordnance ought to have its Shot within one quarter of an Inch of the Diameter of the bore; others do ſay, that the one and twentieth part of the Diameter of the Piece's Cylender is more proper and correſpondent for all ſorts of Pieces whatſoever; Every man may make choice of that which by experience he finds beſt.

CHAP. XXX.

How a Gunner ought to charge a Piece of Ordnance.

HAving ſhewed the compleat making of Pieces of Ordnance, and the preparing of powder and Shot, with the due allowance of powder fit for every Gun, with all the Inſtruments and Materials neceſſarily belonging to a Piece, as to its Rigging and Loading; It remains now, that we go *Artiſt like* to work to charge a Piece, and order all things for the beſt conveniency, and that the leſs danger may follow when you come to Action or Service; and for that purpoſe having planted your Piece upon the plat-form, have in readineſs powder, Bullets, Linſtocks, Scowrers, Rammers, and the reſt of your things. Stick up your Linſtock to Leeward of you; then to work with your Piece. Firſt, cleer your *Piece* within with the Scowrer, and ſee that the touch hole be clear, and not ſtopped, and ſo clear, that no dirt or filth be in the ſame; Then let him that is by to aſſiſt, (*for* a Piece cannot be managed by leſs than two) bring the Budg-barrel with the powder juſt before the mouth of your Piece, put then your Ladle into the ſame and fill it, and if it be over-full, give it a little jog, that the overplus may fall down again into the barrel; after this, put it gently in at the mouth of the Piece, even until the end of the Ladle be thruſt up to the Britch end of the *Piece*; then muſt you turn the Ladle gently and ſoftly, and let it lie within the Chamber of the piece, drawing out your Ladle almoſt to the Muzzle of the *Piece*, put it back again to take up the looſe corns, which were ſpilt by the way, and to bring them up to the Charge of powder; this done, the Gunner muſt draw out his Ladle, and take out of the Budg-barrel a ſecond Ladle full, (by our former Rules given he muſt know the quantity of powder that his *Piece* will require) and ſo putting it in the *Piece* up to the former Ladle-full, then you may draw it out, and do as you did before, that no looſe corns may lie in the bottom of the *Piece*; and in drawing out his Ladle, he muſt have a care that he let not fall any powder upon the ground; for it is a thing uncomly in a Gunner, to trample powder under feet. Then take a wiſp of Straw, Hay, or any other thing, and put it hard in at the mouth of the *Piece*, then turn your Ladle end for end to come to the Rammer, thruſt it into the *Piece* after the wiſp, and drive it up with it, and it will carry all the looſe corns which poſſibly may be ſcattered in the Mold of the *Piece*; having driven the wad up to the powder, give it two or three gentle ſhoves to make it lie cloſe only, but drive it not too hard leaſt you break your powder too much, which would hinder its farce; The wiſp or wad being cloſe to the powder, draw out the Rammer and put in the Bullet, which rowle gently in the *Piece* up to the wad that was before put in to keep up the powder; the Shot being in, put in a ſecond wad after the Bullet, and thruſt it alſo home to

the Bullet. Always remembring whilſt the powder is putting in and wadding up, one be ready at the touch hole and keep it ſtopt with his thumb, that no powder fly out at the touch hole, but that it be likewiſe filled with powder, which may be ſupplyed out of his powder-horn.

The Gunner that Loads a Piece is to be very careful, and indeavour always not to ſtand before the muzzle of his Piece whilſt he is loading the Piece, but on one ſide of the ſame, leaſt a danger or miſchief might happen to him. And thus the Piece having its due Charge of Powder and Bullet, he muſt cover the touch-hole with an Apron made of Lead, or for want of that, with dryed Sheep-skin; then let him level his piece and ſet away the Budg-barrel of powder with the reſt of his things, in ſome hollow place under the ground covered over ſafe; he muſt then attend the Gentleman of the Ordnance, or other chief Commander, their Order or Command, before he give fire.

Touching the Charges of Pieces, I have given full inſtructions neceſſary thereunto, with the weight of powder and Shot for any piece. But to ſay ſomething here touching the quantity of powder, proper for a Load; we do find ſome difference amongſt Authors; Some whereof do maintain, that there ought to be allowed to every Piece for its Charge ſo much powder as half the weight of the Bullet; others are of the opinion, that the more powder is put into a *Piece*, the ſwifter and farther the Bullet will flye, urging many reaſons to prove it. But experience, the Miſtreſs of this Art inſtructeth us better, for if a *Piece* be loaden with two thirds of the weight of her Shot in powder, it ſends the Bullet or Shot going more ſwiftly, and will carry it farther, which hath been very many and often times tryed, ſo that at this time, 'tis without contradiction.

Again, others do maintain, that if one ſhould forcibly Ramme the Bullet, then the powder might take fire before it caſt forth the Bullet, and then would cauſe the Bullet to flye farther than otherwiſe it would do; but you muſt conſider in ſo doing, you either endanger the breaking of the piece, or elſe the making it crooked and unſerviceable; becauſe your ordinary Pieces will not bear ſo great a Charge of powder. This hath been tryed by the Sea ſide before his Excellency *Prince Maurice*, of famous memory, where firſt one and the ſame *Piece* was Loaden with ten pound of fine powder, to ſee how far She would carry the Buller; the place being marked where the Bullet reſted. The *Piece* was loaden again with nine pounds of powder which ſhot as far as when the *Piece* was *Loaden* with ten pounds of powder. But laſt of all, this piece of Ordnance being Loaden or Charged with 7 pounds of the ſame powder, it carried her Bullet further than the two former Shots; whence one may obſerve that a piece of Ordnance may be over-Charged, and therefore a good Gunner ought to have a ſingular care to give unto his *Piece* her due meaſure and Charge.

CHAP. XXXI.

Of the Office and Duty of a Gunner, with all his Properties, Endowments and qualifications.

HE that intends to be a Maſter Gunner, and would not abuſe himſelf nor others of the ſame profeſſion, muſt be qualified according to our Inſtructions following, *viz.*

He ought to be well skilled in Arithmetick, and to underſtand the Extraction of the Square and Cube Roots, and to have knowledge in Geometry, according to our Inſtructions

Inſtructions in the ſecond part, whereby he may be able to take heights, depths, breadths and lengths, and to draw the plot of any piece of ground, to make Mines and Countermines, Rampars, Baskets of earth, and ſuch like things uſed in time of war, as well offenſive as defenſive.

He ought moſt chiefly upon Land-Service to be well skilled in the making *Plat*formers, with Defences, Troniers, Gabbions, Loops, *Parapets* of Earth, and Faggots of 23 or 24 foot high; two foot high of Earth, bed upon bed, unto eleven foot high, and after three foot *Terra plene*, to raiſe the Tronniers and Loops, ſo that for the Cannon it be three foot wide in the Barbe, and within twelve foot wide, without the lower part thereof to deſcend Scarp-wiſe, the better to diſcover the Enemies avenues and offend them more freely, for avoiding the blaſt and Smoak and ruine it would elſe make: for Culverin two foot and a half within, and nine foot without will ſerve; and for leſs *Pieces* the leſs meaſure.

If the Battery be to be made with Gabbions, they being filled with Earth without Stones, moiſtned and Rammed 7 foot in Diameter, three Ranks between two *Pieces*, if the place will permit, or two at leaſt; and three Rows alſo one before the other, ſetting one between two, ſo that if one Rank will have three, the ſecond will have two, and the third one; but it will be hard to make a ſafe Battery with Gabbions, Cannon or Culverin proof.

Concerning *Flat*-forms. Let the platform for a Cannon have thirty foot for reverſe, and 27 foot for a Demy-Cannon, and he ought to ſee that his plat-forms be even, or riſing one foot for 20 foot backward the better to ſtay the Reverſe, and facilitate the bringing the piece when Loaden to the Loop. The platform ought to be made clean, that no ſtones or other things lye in the way for the wheels to run upon, whereby may be hindered the true intent of his Shot.

He muſt before any ſervice is, examine his Piece of its goodneſs or defect; according to our former Inſtructions given in this behalf, he muſt alſo be furniſhed with all neceſſary things for his Artillery, the particulars thereof we have mentioned in the 29 *Chap.* but becauſe it takes not up much paper we will repeat them here again, *viz.*

Wheels, Trucks, Axeltrees, Ladles, Rammers, Spunges, Worms, Tampions, height-board, Auger-bit, fineſs and roundneſs of the Shot, Chane-Shot, Croſs-bar Shot *&c.* Canvas or ſtrong paper for Cartredges, Calabers, Compaſſes, Sight Rule, Gunners Scale, Quadrant, Scales, Weights, priming-Irons, and Aprons to cover the Touch hole.

Before he come upon Service, he ought to examine and prove the goodneſs of his *Powder* and Match, and examine it according to the Rules given where we treat of the Examination of the goodneſs of *Powder*.

A Gunner ought to be moſt careful to ſee that the *Powder* be placed ſafely from danger of his own, as alſo the Enemies Ordnance, and to be furniſhed with artificial Torches, Dark Lanthorns, with all ſorts of Fire-works, of which you ſhall have a particular account in the Treatiſe of Fire-works at the end of this Book.

He muſt have by him his Gyn and Winch, Hand-Spikes, Crowes, to mount and diſmount Guns at pleaſure as occaſion may ſerve, alſo Coynes, Budge-Barrels, *Powder* Baskets to carry Shot to your *Piece*, to keep his Linſtocks well armed with good Match.

He muſt alwayes have by him a Ruler, Scale, Compaſſes, to meaſure the Diameters or Bore of every *Piece*, and likewiſe the length of the Cylinder within, the better to fit her with due Shot and *Proportion* of *Powder*.

He muſt learn by ſuch Inſtructions as we have already given, the Names, Length, Weight, and Fortification of every *Piece* about the Chamber, and to tell readily how much *Powder* is a due Charge for every *Piece*, and what Shot is neceſſary. How many *Perſons* muſt attend in time of Service, how many Horſes or Oxen will draw a *Piece* of Ordnance, and in caſe they be wanting, how many men will ſerve. How many pound weight of Shot one man may drive before him in a Wheel-barrow from place to place.

A Gunner ought chiefly to Charge and Diſcharge a Piece of Ordnance Artiſt like; and when he opens, or orders to be opened the head of a Powder Barrel, let no Iron Tool be uſed thereunto for fear of taking or ſtriking fire; for that purpoſe therefore it is uſual to have wooden Mallets, which will prevent ſuch dangers.

Every Gunner before he beginneth to make a Shot, ought to conſider that a wad of Hay, or of untwiſted Ropes, will make the Shot ſhoot wide of the Mark.

He ought to conſider whether the Trunions be placed in their due place in the Carriage, whether the Carriage have its due length, whether one wheel be not higher than the other, or whether one wheel doth not reverſe quicker or ſooner than the other, for theſe will cauſe the Piece to erre, and to ſhoot wide of the Mark.

Every Gunner ought to conſider, that if his Piece lye point blank or under Metal, then he ought to put in a ſufficient wad after the Shot, to keep it cloſe to the Powder; for if it ſhould not be cloſe, great danger might follow; for if the Shot ſhould lodge any diſtance from the Powder, then in the firing of that Piece it would break off in that very vacant place between the Shot and the Powder, and ſo do dammage to himſelf or ſtanders by. If your Piece be mounted, you then uſe no wad at all after the Shot.

Every Gunner ought to have ſtanding by him ſome Tubs of water to wet his Spunges in, whereby to cool his Piece in time of Service, as alſo to be ready upon occaſion to put out any Fire that might happen in time of Service.

Every Gunner ought to try whether his Piece is truely bored or not; if it be not, he is to take it into conſideration, and to order his proportion of Charge, according to the thinneſt part of the Metal, to prevent all danger.

A Gunner ought to take his Obſervation of the Mark or place he intends to direct his Shot to, juſt over the middle of the bore within the Piece, for by this means he may be able, by his Skill, to make a true Shot in a bad Piece.

A Gunner, that he may the better direct his Shot to the place deſired, ought to conſider the difference of the Metal of the Piece at Britch and Muzzle, and thereby truely how to diſpart a Piece, be it either true bored or not. Of diſparting a Piece, I ſhall ſhew how it may be done ſeveral wayes in the following or ſecond part of this Gunnery; where we come to the practical part of the Art in handling a Piece of Ordnance upon all occaſions.

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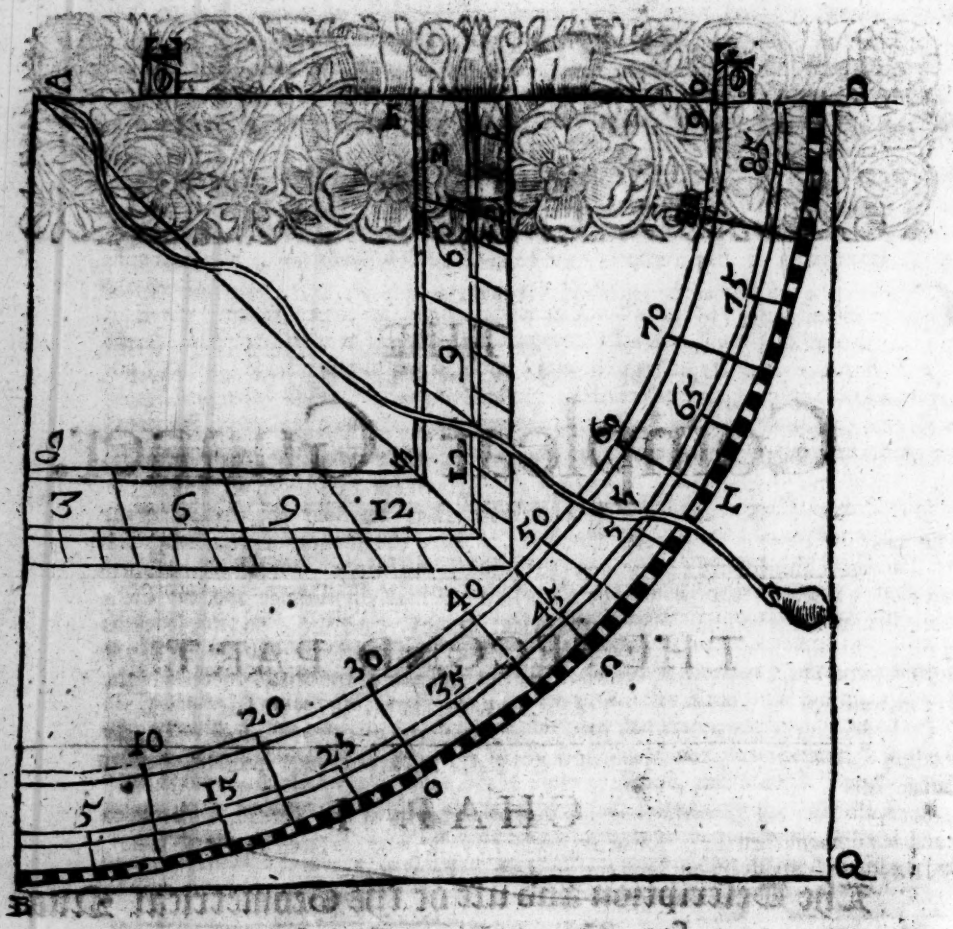
THE Compleat Gunner.

THE SECOND PART.

CHAP. I.

The Deſcription and uſe of the Geometrical Quadrant, for the taking Heights, Diſtances, Depths, &c.

FIrſt, you muſt make a common ſimple large Quadrant thus with your Ruler, draw the Line A B, and with the Diſtance A B in your Compaſſes upon the Center A deſcribe the Arch B D, then with the Diſtance A B, ſetting one foot of your Compaſſes in B, ſet it off upon the Arch B D, and it will reach to L, divide the Arch B L into two equal parts and that will be at E; The diſtance O L, being ſet upwards from L, will reach to D; ſo then drawing the Line A D, will make the Quadrant A B D, and the Arch B O L D will be divided into three equal parts; now every one of thoſe parts muſt again be divided into three equal parts, and every one of them into 10 equal parts, ſo will your Quadrant be divided into 90 equal parts, called Degrees.



Of the Scale.

From any part of the Lines A B and A D, at equal distance from the point A, as at *g* and *h*, raise two perpendicular Lines which will meet in the point *m*, which we divide here into 12 equal parts, but may be divided into 100 or 1000 equal parts at pleasure, and the more parts they are divided into, the more exact will your work be; let these Lines *g m* and *h m* be marked into the Divisions from the point A.

Let two sights of Brass be placed upon the Limb of your Quadrant, at the places marked E and F.

Let the Division upon the Line *h m*, being next the sights, be turned right shadows, the Division upon the side *g m*, left or contrary shadows.

Let a Line with a Plummet be fixed to your Quadrant falling from the Center *A*, as you see in your Figure.

CHAP.

CHAP. II.

The Use of this Quadrant in taking the Perpendicular or direct height, by help of the Suns shadow.

CONvey the left side of the Quadrant Geometrically towards the Sun, the Thread and Plummet having their free course, moving it up or down until both your sights have received the Sun-beams; then if your Thread be found in the twelfth part, all things that are upright or truly perpendicularly elevated, are equal in height with their shadows.

If the Thread with the plummet be observed to cut any of those parts next the sights, called right shadow, between *m* and *h*, then every upright thing is more than the shadow, by such a proportion as 12 exceeds the parts where the Thread was found.

If the Thread fall upon the first division, then 12 times the shadow is the height. If it fall upon the second Division, 6 times the shadow is the height. If it fall upon the third Division, 4 times the shadow is the height. If it fall on the fourth Division, 3 times the shadow is the height. In the fifth Division twice and two fifths of the shadow is the height. In the sixth twice, in the seventh once, and five sevenths in the eighth Division, one and a half in the ninth, one and a third in the tenth, one and a fifth part in the eleventh, once and the eleventh part of the shadow is the height on the twelfth part, then the length of the shadow is the height, as we said before.

Or in few words it may be done thus, Multiply the length of the shadow by 12, the product divided by the parts in which you found the Thread, your quotient sheweth the height.

But if the part cut be on the contrary shadow, that is, if the Thread fall between *g* and *m*, augment then the length of the shadow by the parts declared by the plummet, and the increase divide by 12, and the product is the Altitude.



Example.

In the Foregoing figure it is plainly to be perceived, when the figure falleth upon the 12 Division, the shadow is equal with the thing it self; In the 6 of the right, it

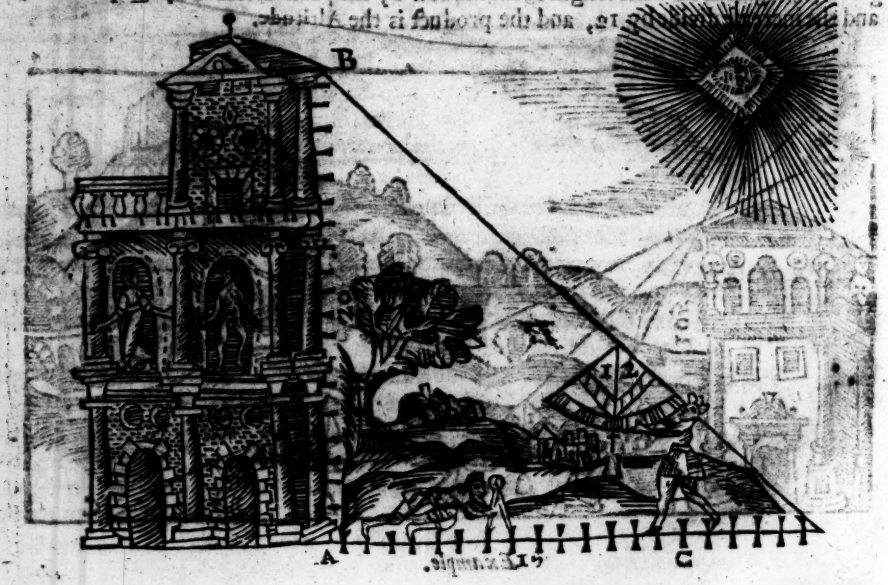
is but half, in the 6 of the contrary it is twice the height, and ſo to conclude, as the ſide in the right exceeds the parts, ſo doth the Altitude the ſhadow; and the contrary in the contrary ſhadow. Behold the figure 6 where you will find the Thread cutteth 6 parts of the contrary ſhadow upon the Quadrant, the ſhadow B C then being 210 foot, multiply (as I have ſaid) the length of the ſhadow 210 foot by 6, the parts cut by the Thread, and it makes 1260, and that divided by 12 riſeth 105, which is the Altitude of ſuch a body, that caſts a ſhadow of 210 feet.

Alſo the height of any unknown thing may be known by taking the length of its ſhadow, and the length of the ſhadow of any ſtaff ſet upright whoſe length is known, ſaying, as the length of its ſhadow is to its height, ſo the length of the ſhadow of the unknown thing is to its height.

CHAP. III.

Without Shadow or any Supputation by your Quadrant Geometrical, to take heights approachable.

If up ingeniouſly your Quadrant exactly made towards the thing to be meaſured, looking diligently through both ſights backward or forward, as occaſion is given, until you ſee the top, ſo that your Line or Thread fall juſt upon the middle of 12 Diviſion; now if you meaſure your diſtance from you to the foot of the Object, which is the point directly under the top, then have you the Altitude of the higheſt ſummitie to the right point or baſe in height equal with our ſtanding, adjoyning with it the height of your eye downwards.



CHAP.

CHAP. IV.

With the Aid of two Stations to find out Inapproachable heights.

SEek two Stations going hither and thither, yea, toward or from the thing you intend to measure, so that in the one place the thread may fall just in 12, and at the other Station in 6 points of a right shadow; then if you double the Distance of both places, the Summitie shall appear from that part of the thing measured, which is equal in height with your Eye; or if your standing be even with the Base, joyning to that double distance the height of your eye, you have the whole Altitude from the ground, *&c.* If the one Station cause the Thread to fall in 12, and the other in 8 of a right Shadow, then triple the Distance between the two Stations, so have you the height also: Or if the one be in 12, and the other in 9 of right shadows, then quadruple the distance, the one under 12, and the other under 6 of the contrary shadow, and the place between both Stations is equal with that you measure, ever understanding from your Eye upwards.

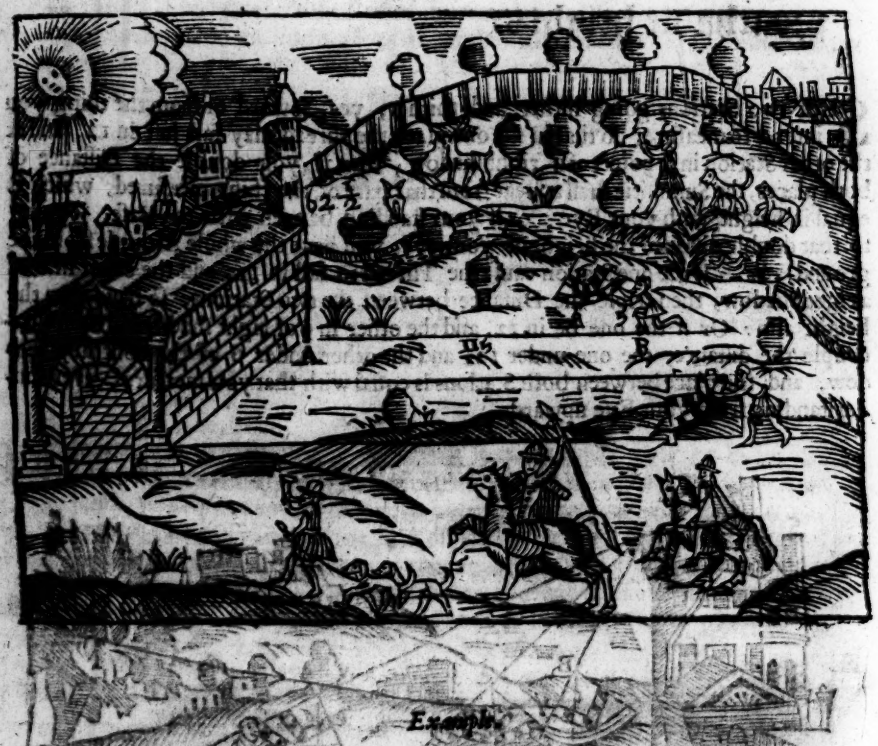


CHAP. V.

How by the Quadrant, with Calculations, speedily to find all heights accessible.

YOur Quadrant, as in the former Figure, handsomly elevated against or towards the thing to be measured, perceiving through both sights just the top, mark well the Division or points crossed by your Thread, whether it be of the right shadow, then multiply the distance between you and the foot of the Object by 12, and divide that Sum by the parts cut upon your Quadrant, which your Thread manifesteth; and the remainder is the height of the Object from your Eye.

But if the Thread fall upon contrary ſhadows, work contrarily, that is, augment it by the part, and divide that Sum by 12; Remembring ever to add the height of your eye downward to your quotient; ſo have you your deſire, the Baſe being equal with your ſtanding.



Example.

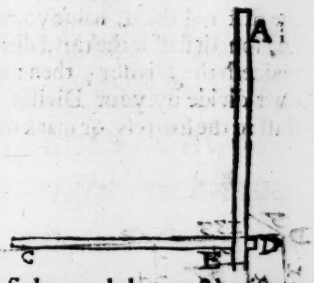
Admit the Thread with the plummet note 6 parts of contrary, as you may ſee in the foregoing figure, the diſtance from the baſe A to your ſtanding B 115 foot multiplied by 6, ſo have you 690, which divided by 12 yieldeth 57½ foot; to this adjoyn 5 foot (being the height of your eye from the ground) and ſo find the Altitude to be 62½ foot.

To find what part of your Altitude is Level with your Eye.

Cauſe the *Plummet* and Thread to fall upon the ſide of your Quadrant where the Degrees begin, which you will find before in the Deſcription of the Quadrant to be the ſide A B, and then ſearching through the Sights that part, that which you can ſpye of your Altitude (the plummet hanging upon the ſaid Line A B) is level with your Eye. the height whereof from the baſe compared with the Altitude of your Eye, diſcovereth the inequality or difference of the ground, that is to ſay, how much higher or lower the baſe of the thing to be meaſured is than the ground at your Station, which difference, as you ſhall ſee cauſe, added or ſubſtracted from your heights found as is before declared, yieldeth moſt exactly the true Altitude: And thus you may be aſſured never to err, how unequal or uneven ſoever the ground be.

You

You may alſo by two things of one length joyned thus in a right Angle, find the Altitude of any thing.



Let the end C be applyed to your Eye, then go backward or forward as you ſhall ſee cauſe, till you can eſpye the top and Baſe of your Altitude by the Extreams A B; and in ſo doing, the diſtance between your foot and the Baſe is equal to the height, without adjoyning the Altitude of your eye, which in all the reſt before ſhewed is required. Only here you muſt take heed ſo to couple A B and C D, that in beholding the Altitude, your Line A B may depend perpendicular or parallel to the height. In like ſort may you mete the diſtance of any two things in ſight, and that exactly, if you uſe diſcretion in placing A B, that it be always parallel to the thing meaſured, which may eaſily be done by help of a Line and Plummet upon the ſide A B.

CHAP. VI.

To Meaſure the Diſtance any place is from the top of a Caſtle or Work.

THis Work is Performed as the former in the 2d. *Chap.* only here with a Plummet and Line we take the heighth or depth from the top of the Caſtle A, to the foot of the Caſtle B, and ſuppoſe that to be equal to the diſtance there taken, and the diſtance B C equal to the height, and then work by the Rules there given, and you will find the diſtance C B. This is ſo plain there needs no Example.

CHAP. VII.

To get the Length or Diſtance of any place or Mark in ſight, be it never ſo far, without Inſtrument.

AMongſt many practices I find this the onlieſt way to obtain our deſire without the help of an Inſtrument, yet in this is neceſſarily required to have ground enough at liberty on one ſide. Then begin thus; at the beginning of your Length ſet up a ſtaff or mark that may be ſeen afar off, then go from it Orthogonal or Square-wiſe on which ſide you will 200 foot; the more ground the better; Put up there a ſtaff alſo: now convey your ſelf to the firſt ſtaff or mark, going back from it 300 foot, more or leſs, at your pleaſure, ſet up there a third ſtaff ſo, that the firſt mark or ſtaff and it agree all in a ſtreight Line from your ſight to the fartheſt part of your length by the judgment of your eye; now go ſide-wiſe from thence as far in a right Angle, until the ſecond mark offer it ſelf aright between the extream part of your length and ſight, and

But if the Thread fall upon contrary ſhadows, work contrarily, that is, augment it by the part, and divide that Sum by 12; Remembring ever to add the height of your eye downward to your quotient; ſo have you your deſire, the Baſe being equal with your ſtanding.



Example.

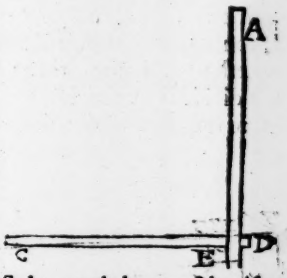
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To find what part of your Altitude is Level with your Eye.

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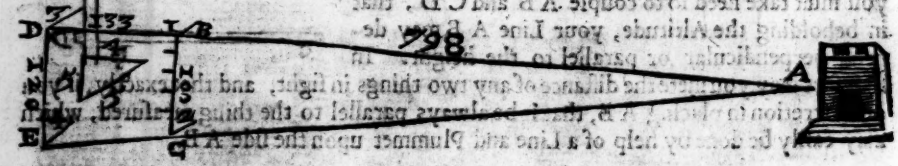
THis Work is Performed as the former in the 2d. *Chap.* only here with a Plummet and Line we take the heighth or depth from the top of the Caſtle A, to the foot of the Caſtle B; and ſuppoſe that to be equal to the diſtance there taken, and the diſtance B C equal to the height, and then work by the Rules there given, and you will find the diſtance C B. This is ſo plain there needs no Example.

CHAP. VII.

To get the Length or Diſtance of any place or Mark in ſight, be it never ſo far, without Inſtrument.

AMongſt many practices I find this the onlieſt way to obtain our deſire without the help of an Inſtrument, yet in this is neceſſarily required to have ground enough at liberty on one ſide. Then begin thus; at the beginning of your Length ſet up a ſtaff or mark that may be ſeen afar off, then go from it Orthogonal or Square-wiſe on which ſide you will 200 foot; the more ground the better; Put up there a ſtaff alſo: now convey your ſelf to the firſt ſtaff or mark, going back from it 300 foot, more or leſs, at your pleaſure, ſet up there a third ſtaff ſo, that the firſt mark or ſtaff and it agree all in a ſtreight Line from your ſight to the fartheſt part of your length by the judgment of your eye; now go ſide-wiſe from thence as far in a right Angle, until the ſecond mark offer it ſelf aright between the extream part of your length and ſight, and

the be put the fourth ſtaff. All this performed, ſeek out the diſtance between the firſt ſtaff and the Second, and that name your firſt diſtance; then the diſtance between the firſt and third, name your ſecond diſtance; Again, the diſtance between the third and fourth ſtaff is the third diſtance; Deduct your firſt diſtance from the third, ſo remaineth the Diviſor; then multiply your third diſtance by your ſecond, and the product divide by your Diviſor, the quotient ſheweth the true length from the third ſtaff to the fortreſs or mark deſired: for plainteſs behold the figure.



Example.

Here this Letter A repreſents the Caſtle, being the diſtance to be meaſured; B is your firſt ſtaff; C the ſecond ſtaff, differing from B the firſt Orthogonal 100 foot; D the third ſtaff, being diſtant back from the firſt in a Right line with the mark A 133 foot; E is the fourth ſtaff, running ſidewiſe Orthogonally, or in a Square, from the third, until the farthest part of your length A, is perceived in a right Line with the ſecond ſtaff at C; and this diſtance D E let be 120 foot. Now by Subſtraction take 100 from 120, there remaineth for a Diviſor 20; then multiply 133 by 120, ſo riſeth 15960, which divided by 20, and there cometh 798 foot, the true diſtance between D and A, from which if you abate A B 133, there remaineth B A your propounded diſtance.

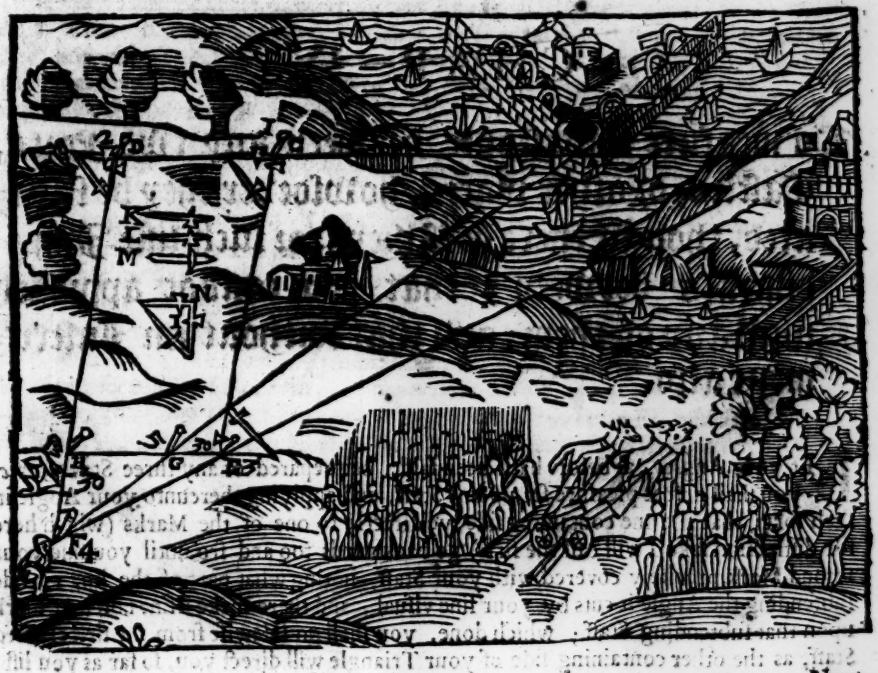
But forasmuch as this concluſion is to be done without Inſtrument, and here Orthogonal motions ſidewiſe is required, it ſhall be requiſite alſo to declare how an Orthogonal or Right angle is upon a ſudden to be made; ye ſhall therefore (according to *Pythagoras* his Invention mentioned among the Definitions at the beginning of this Book) take 3 Staves, Cords, or ſuch like, making the one 4 ſuch parts, as the other is 3, and the third 5; This done, conjoyn their ends together, and the angle ſubtended of the longeſt ſtaff is a right, which firſt placed at B, and after at D, directing one of his comprehending ſides to A, the other ſhall guide you to C and E; or if you deſire with more expedition to diſpatch, and not to tarry the proportioning of Cords, or ſuch like, to this Pythogarick Rule, take any 3 Staves, Sticks, or Threads, and conjoyn them, making a Triangle, it matters not of what form or faſhion they be, firſt placing one angle thereof at B, turning one ſide to A, direct your ſelf ſidewiſe to the other, alwayes remembring to place the ſame angle at D, and departing ſidewiſe again in like manner, in all the reſt do as before is declared. Thus uſing any mean diligence, yuo ſhall moſt exactly meaſure any diſtance.

CHAP.

CHAP. VIII.

With Halbeards, Pikes, or any Staves, having no other Inſtrument, you may meaſure the Diſtance between any two Towers, Caſtles, or other Marks, lying in a right line from you, not coming near any of them.

YOu muſt firſt (as we have declared in the laſt Chapter) prepare a Triangle, with joyning any three Staves, or ſuch like, together, which you muſt (at your ſtanding) place in ſuch ſort, that one of the ſides containing the Angles, may lye directly toward the Mark: Then ſetting up a Staff, Pike, or other Mark there, depart ſidewiſe, as the other ſide of your Angle ſhall direct you, ſo far as you liſt, the more ground the better, and there ſet up your ſecond Staff or Mark, then go directly back from your firſt Staff (alwayes keeping it exactly between your ſight and the Mark) as many ſcore again, or Pike lengths, as you liſt, ſetting up a third ſtaff; this done, you ſhall place the ſame Angle you uſed at your firſt Staff now again at your third ſtaff, in all points as it was before; the one ſide of the Angle lying directly toward the firſt Staff, the other ſide will ſhew you whether you ſhall go to place your fourth Staff; for paſſing ſtill in a right line with that ſide of your Angle, you ſhall at the laſt find the ſecond juſtly ſituated between you and the farthеſt Mark, and there ſet up the fourth Staff; then remove your Angle again to the ſecond Staff, and placing there as before, the one ſide even with the firſt Staff, paſs on in a right line with the other, until you come directly between your neareſt Mark and the fourth Staff, and there pitch up the fifth.



Now you muſt meaſure how many Paces, Halbeards, or Pikes length, are between your firſt and ſecond Staff, deducting that from the diſtance between the third and fourth, and the Remainder ſhall ſerve you for a Diviſor; then multiply your diſtance between the ſecond and fifth Staff by the diſtance between the third and fourth, the product divide by your reſerved Diviſor, and it yieldeth in the Quotient the true diſtance between theſe two Marks. See the foregoing Figure.

Example.

Let A B be the two Marks, whoſe diſtance I would meaſure; my ſtanding place where I ſet up my firſt Staff, I; in the middle, my Triangle made of three Staves, Halberds, Bills, or any ſuch like things, K L M; the Staves or Halberds of which I make my Triangle N, which I firſt place at C, ſecondly at D, thirdly at E; and note, at C and D the ſcituation of the Triangle is all one, but at E it ſomewhat differeth, as you may behold in this Figure, which I would have you note, leſt haply you be deceived in your practice.

C E the diſtance between the firſt and third, deducted from D F the diſtance between the ſecond and fourth, there remains H F your Diviſor; which meaſured, I admit 50 Halberds lengths, the diſtance between G E 30 Halberds lengths, the ſpace between D F 100 Halberds length; now 100 multiplyed by 30 produceth 3000, which divided by 50, leaveth in the Quotient 60. I conclude therefore the diſtance between A and B to be 60 Pikes lengths.

This one thing is to be taken notice of eſpecially, that whatſoever you mete the ſpace G E withall, that you uſe the ſame in meaſuring H F; and as for D F it matters not what you meaſure it withall, for your Quotient ſhall bear the ſame denomination. Preciſeneſs is to be uſed in placing of your Triangle, and in meaſuring E G, and H F, otherwiſe error may enſue; eſpecially if D F be but a ſmall diſtance, and the Angle at B very ſharp. There needeth in this matter no further admonition, ſmall Practice will reſolve all doubts.

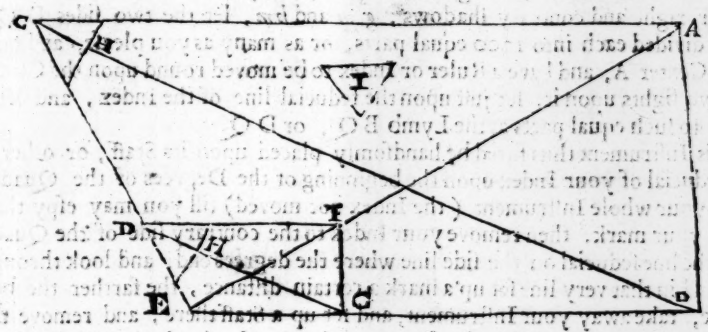
CHAP. IX.

To meaſure the diſtance between any two Forts, Caſtles, or other places, howſoever they be ſcituated, though there be Rivers, or ſuch like Impediments between, that you cannot approach nigh any of them; and that without an Inſtrument alſo.

LEt your Angles, as before hath been ſaid, be prepared of any three Staves, *&c.* you ſhall firſt at pleaſure ſet up one Staff, and applying thereunto your Angle in ſuch ſort, that the one containing ſide lye directly to one of the Marks (which here for diſtinction ſake I will call the firſt) go backwards too and fro until you find your ſecond Mark preciſely covered with your Staff, noting what part of the line or ſide ſubtending the Angle it cuts by your line viſual, and there make a fine notch or mark upon that ſubtending Staff; which done, you ſhall go ſidewiſe from the firſt erected Staff, as the other containing ſide of your Triangle will direct you, ſo far as you liſt,

and

and then ſet up your ſecond Staff; yet paſs on from thence in a right line with that containing ſide of your Angle that riſeth from your Staves, and cometh ſomewhat toward the Mark, and go ſo far until you ſpy your ſelf juſt between your third Staff and your firſt mark, there ſet up your fourth Staff; then reſort to your Angle again, and ſtanding behind the ſecond Staff, note whither a right line from the Angle to that notch (before made on the ſubtendent Staff or ſide of the Triangle) will direct you, for that way preciſely ſhall you go on until you come in a right line with the ſecond and third Staff, and erect there the fifth Staff; this done, meaſure the diſtance between the ſecond and third Staff, reſerving that for a Diviſor; then multiply your diſtance between the firſt and third Staff, by the diſtance between the fourth and fifth Staff, the product divide by your reſerved Diviſor, and it yieldeth in the Quotient the true diſtance between the two marks.



Example.

Let A B be the diſtance I would know, C my firſt Station where the firſt Staff is erected; I my Triangle made of three Staves, and placed at the Station C, directed with one of the containing ſides to A, which is the firſt mark, as you may ſee in the Figure, and with the other ſide to D and E the ſecond and third Staves; H is the notch or mark upon the ſide ſubtended to the Angle, where the line viſual from C paſſeth to the ſecond mark B; my Triangle now I ſituate at D, as it was before at C; the one contained ſide lying even with the erected Staves, the other directed to my fourth Staff F, placed in a right line with E the third Staff, and A the firſt mark. Again, my line viſual proceeding from D to H, the notch in the ſubtended ſide of the Angle is extended to my fifth Staff G, ſituated exactly between E the third Staff, and B the other mark: This done, I meaſure the diſtance between my ſecond and third Staff, finding it 20 foot; likewiſe between the fourth and fifth Staff, and find it 72 foot; finally between the firſt and third Staff 65 paces; ſo that according to the Rule before given, multiplying 65 by 72, I have 4680. which divided by 20, yieldeth in the Quotient 234, and ſo many paces is there between A and B.

I have not ſet out the Figures in juſt proportions anſwering to theſe numbers, for that is not requiſite, but in ſuch form as may beſt open and make manifeſt the ſituation of the Staves and Triangle, wherein conſiſts all the difficulty of this Practice.

CHAP. X.

How you may readily find out the distance to any Tower, Castle, Forts, &c. by help of the former Quadrant.

LEt the Quadrant be made upon a square Board as is there marked A D B Q. Let D B be divided into 90 Degrees or equal parts; and instead of the 12 equal parts, or right and contrary shadows, *g m* and *h m*, let the two sides D Q and B Q be divided each into 1200 equal parts, or as many as you please, and marked from the Center A, and have a Ruler or Index to be moved round upon the Center A, having two sights upon it, set just upon the feducial line of the Index, and let it be divided into such equal parts as the Lymb B Q, or D Q.

Let this Instrument thus fitted be handsomly placed upon its Staff, or otherwise, lay the feducial of your Index upon the beginning of the Degrees of the Quadrant, and turn your whole Instrument (the Index not moved) till you may espy through the sight your mark, then remove your Index to the contrary side of the Quadrant, placing the line feducial on the side line where the degrees end, and look through the sights, and in that very line set up a mark a certain distance, the farther the better; this done, take away your Instrument, and set up a Staff there, and remove the Instrument to the mark you espyed; set your Index on the beginning of the Degrees, moving your whole Instrument, till you find through the Sights the Staff at the first Station, then remove your Index (your Quadrant keeping its place) till you may again espy through the Sights your mark; which done, note the Degrees cut by the line feducial, and then work thus; upon some even smooth Superficies, whether it be Board, Plate, or Paper: Draw first a streight line, and open your Compasses to some small distance, call that space a score, and make so many such divisions upon your Line as there is scores between your Stations, then upon the end of your line raise a perpendicular, and fixing one foot of your Compasses at the other end, opening it to what wideness you please, draw an Arch rising from the same line that represents your Stationary distance, and dividing it into 90 equal parts or Degrees (as you was taught in the making your Quadrant) extend from the Center to the number of Degrees cut by your feducial line, a right line, until it concur with the perpendicular before erected, then see how much of that space (which represenceth the score in dividing your Stationary distance) is contained in the perpendicular, so many score is the mark off from your first Station, and by dividing the Hypothenusal line, you may find the Distance from the second Station.

Example.

A the first Station, C the second, D the mark, A C 80 paces, Degrees of the Quadrant cut by the line feducial at the second Station is 71 d. ½, and H is the unity or measure representing one score, E F 4 parts, G F 12, G E 12 ⅓, or thereabouts: Thus may you conclude the mark to be distant from the first Station 12 score paces; the Hypothenusal line or distance of the mark from the second Station, 12 score and 13 paces.

See the Figure.



To perform this Work by Calculation.

In the foregoing Figure, B is the place to be measured, A the mark where I first disposed my Instrument, from it I go Orthogonally to C, the Index suppose cuts there 400 in the right side of your square; the distance between B and C, I have supposed 80 paces; wherefore multiply 1200 by 80, and there cometh 96000, which divided by 400, declareth unto me 240 paces, the true length from A to B. Or by dividing 1440000, the square of 1200, with 400 the parts cut, you shall produce in the Quotient 3600, your proportionable part found by the Rule of Reduction, which augmented in 80, yieldeth 288000, and that divided by 1200, bringeth in the Quotient 240, which is the length A B agreeing with the former operation.

But if you would find CB, or the Hypothenusal line, being the distance between the second Station and the mark; then by the former Table of Squares, or with your Pen, find the Square of A C, and the Square A B *the distance* already found from the first Station, these two Squares added together, the Square Root of that Sum is the distance C B, *viz.* 253 paces; or if the Sum of the Square of A B and A C be sought for in the Table of Squares, you will find against it 253 paces, the length of C B, which was to be found; for the Square of A B more, A C is alwayes equal to the Square of C B, and the Square of C B less, the Square A C is equal to the Square of A B.

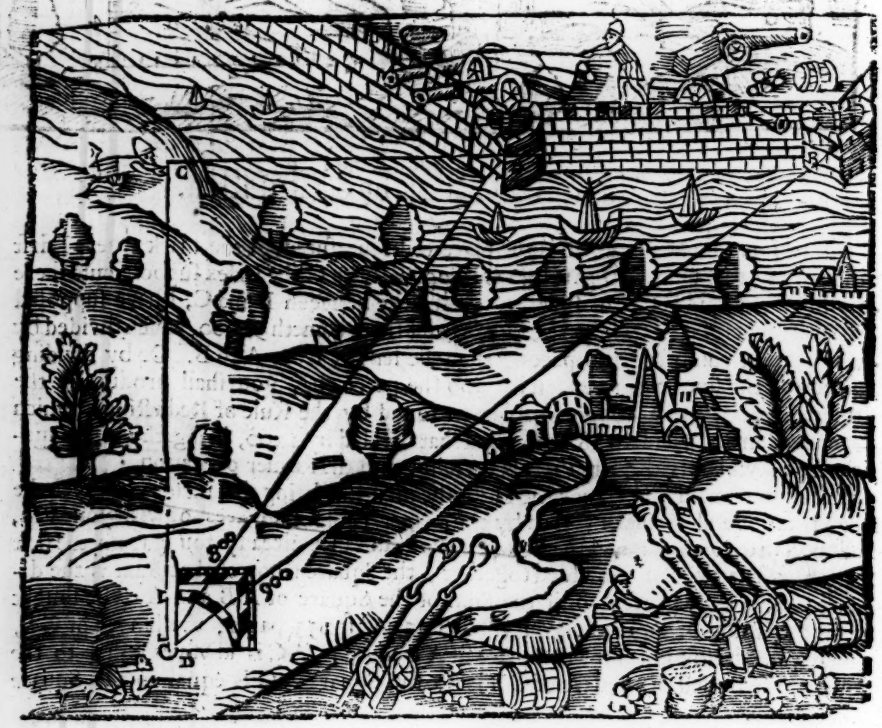
CHAP. XI.

To measure the distance between any two marks that lye in one right line from the Eye.

THis may be resolved by the former Proposition, measuring how far either distance is from your self, and then deduct the one from the other; or thus, another way, the side of your Geometrical Square directed towards them, depart Orthogonally, as is before declared, 100 or 200 paces at your pleasure, but the more the

better; then place your Inſtrument again, turning the ſide of it towards the firſt Station, remove then the Index to either marks, noting what parts at either place the Index doth cut of the Scale; and if the Index at both times falls on the left ſide, deduct the leſſer from the greater; with the number remaining, augment this diſtance between your Stations, and dividing by the whole ſide of the Scale, your Quotient is the diſtance. If the Index fall on the right ſide at either time, then muſt you by the Rule given in the Ninth Chapter, reduce them into proportional parts; or if at one time it fall on the left ſide, and at another time on the right, then ſhall you only reduce the parts cut on the right ſide; which done, deduct as before is ſaid, the leſſer from the greater, and with the remainder multiply your diſtance Stationary, the product divided by 1200, yieldeth how far one mark is beyond another.

Behold the Figure.



Example.

Admit A B the marks in a right line from C your firſt Station, D the ſecond Station Orthogonally ſcituated from C, where your Square being placed, ſuppoſe your Index firſt cut 800 parts on the left ſide, and after 900 parts on the right ſide; you muſt divide the Square of 1200 by 900, as was taught in the former Chapter; ſo will your Quotient amount to 1600, from which if you withdraw 800, the parts cut on the left ſide, there will remain 800, which multiplyed by 200 paces, the diſtance Stationary C D, there amounteth 160000, this divided by 1200, yieldeth in the Quotient 133 $\frac{1}{3}$; therefore the diſtance from A B, your mark, is 133 paces, 1 foot, and 8 inches.

CHAP.

CHAP. XII.

To measure the Distance between any two marks lying in one plain level ground, howsoever scituated, without Arithmetick.

THis at two Stations may be done, as we have done before; but we will here suppose but one Station, knowing the distance from that Station to each place, and the Angle it makes with each Station; then by help of a pair of Compasses, and any line of equal parts, this is most easily wrought, as is well known to small Practitioners in this Art, it being also the 4th Question in Right-lined Oblique Triangles.

I did intend to shew the working of every one of these Questions by Logarithms; but considering a Gunner hath not alwayes such Tables by him (and if he have them and understands right-lined Triangles, doubtless he may easily apply them to this work) I therefore thought what I have done in this case to be sufficient.

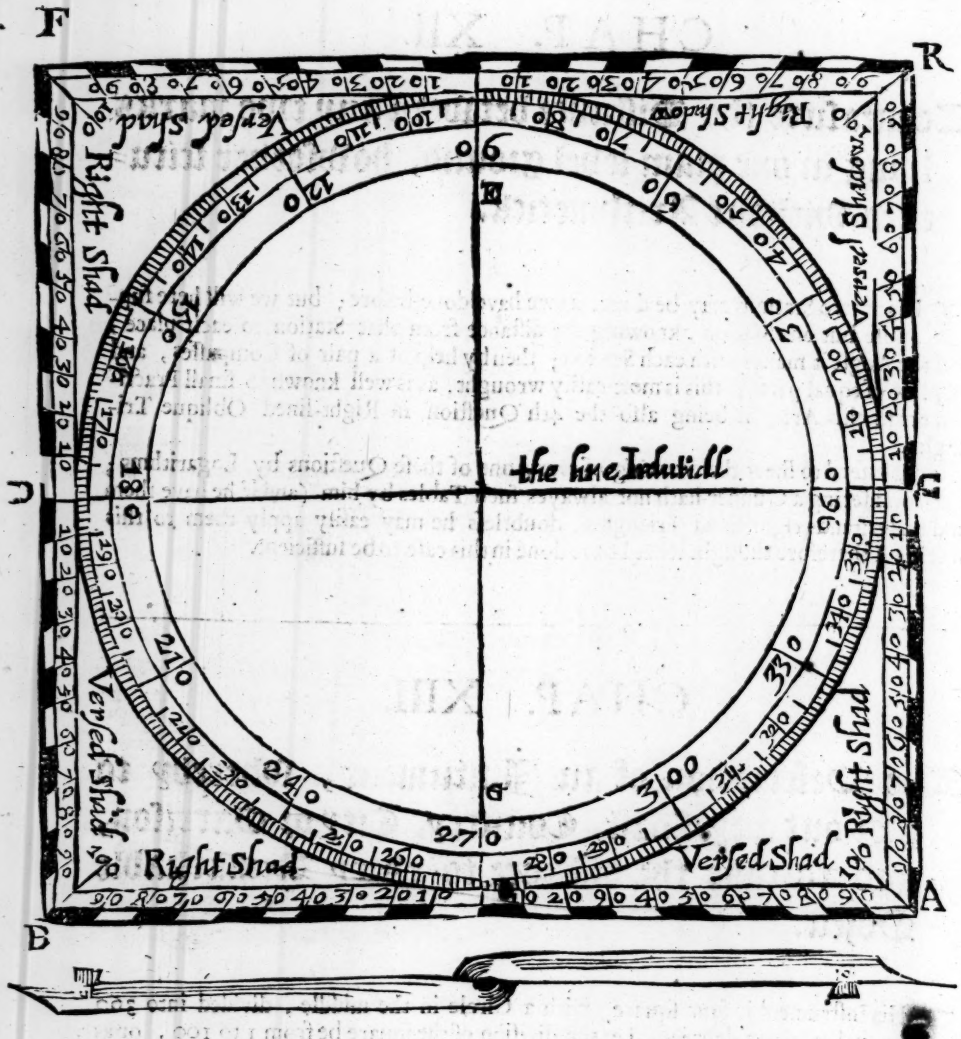
CHAP. XIII.

The Description of an Instument, whereby to plot out any Coast, Country, City or Garrison, and to take the distance to every Remarkable Object.

THis Instrument is four square, with a Circle in the middle, divided into 360 equal parts or degrees. Let the division of the square be from 1 to 100, or as many as you can; you must also have fixed to it an Index, with sight upon the same, as you may see by the Figure following in the next Page. It is called a Circumferenter or Geometrical Square.

To draw a Plot of any Coast or Country in such sort that you may readily tell how far any place is distant from you, or one from another.

YOu must ascend some high Tower, Hill, Cliff, or other place, from whence you may commodiously behold on every part those places you intend a Plot of, there set up your Instrument upon its staff, and in such sort place it by help of your Needle, that the four Semi-Diameters stand due East, West, North, and South; then turn your Index to Town, Village, Haven, Road, or such like, espying through the Sights the middle or most notable mark in them, noting withall in a Table by it self the degrees cut by the Index in your Instrument, which we call the Angles of position, and so make a Table of the first Station. Then search out



with your Eye, viewing round about, ſome other lofty place, from whence you may behold again all theſe places, for that ſhall be your ſecond Station, and turning thereunto the Index of your Inſtrument, note what degree it toucheth; this done, remove your Inſtrument thither, and place it in all reſpects as 'twas before, and turning the Diameter or Index of your Inſtrument to every place, eſpying through the Sight all ſuch marks as you ſaw before, noting again the degrees cut, or Angles of poſition, writing the names of every place, and its degree by it; ſo have you a Table alſo of your ſecond Station; with theſe Tables you ſhall reſort to ſome plain ſmooth ſuperficies of Board, Parchment, Paper, or ſuch like, and thereon deſcribe a large Circle, divide it into 360 degrees, like to the Circle of your Inſtrument; then from the Centre thereof to every degree noted in your firſt Table, extend ſtreight lines, writing upon every one of them the name of his place; and upon that line that repreſents your ſecond Station fix one foot of your Compaſſes, opening the other at pleaſure, and draw another Circle, and divide it alſo into 360 degrees, and from the Center thereof extend right lines to every degree noted in your ſecond Table, writing as before upon every one of them the name of their places or marks; finally, you ſhall note diligently the concourſe or croſſing of every two like lines, making thereon

a ſtar or ſuch like mark, with the names of the places thereunto belonging. Now if you deſire to know how far every of theſe Towns, Villages, *&c.* are diſtant from each other, you ſhall do thus, meaſure the diſtance between your Stations by Inſtrument or otherwiſe, as you have been before taught, and divide the right line between the Centers of your Circles into ſo many equal parts or portions as there are Miles, Furlongs, or Scores, between your Stations; then opening your Compaſſes to one of thoſe parts, you may meaſure from place to place, alwayes affirming ſo many Miles, Furlongs, or Scores (according to the denomination of that one part whereunto you opened your Compaſſes) to be between place and place, as you find by meaſuring there are parts.

Example.

There is a Sea Coaſt having ſundry Harbours, Towns, Villages, Caſtles, and ſuch like ſcituated thereon, whoſe Plot in due proportion I require, with the exact diſtances of every place one from the other.

Having therefore elected a lofty ſeat, from whence I may behold all theſe places (my Inſtrument ſcituated as is declared) removing the Index to a Caſtle that is fartheſt, being a Caſtle ſtanding in the mouth of a Haven, having received it through my Sights, the line fiducial of my Index cutteth 30 degrees; then I remove it to the next, being a Village or Fifth Town, and the Index cutteth 50 degrees, and ſo round to all the reſt; and thus I ſhall have the Table of my firſt Station, as followeth,

The Table of my firſt Station.

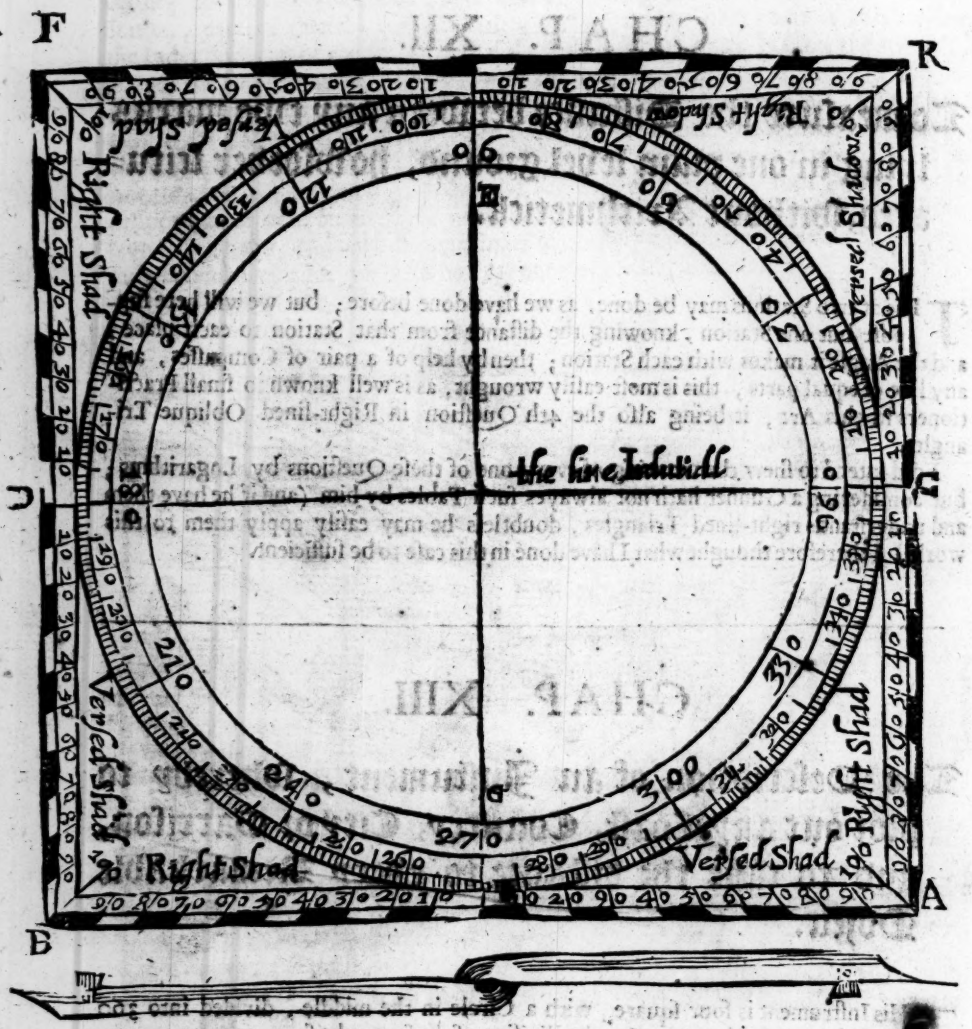
	Deg.
The Caſtle.	30
The Village.	50
The City.	75
The Eaſtern Head of the Bay.	95
The Weſtern Head of the Bay.	97½
The Fort within Land.	130.

This done, I behold another Hill or high place; from whence I may in like manner view all thoſe places, and turning my Index thereunto, I find the Line fiducial lying upon 180 Degrees; then carrying my Inſtrument thither, and placing it in all points there, as it was at the firſt Station, I turn my Index again to my firſt Mark or Caſtle, and find it to cut in 15 Degrees, at the ſecond 25, *&c.* as you may ſee in this ſecond Table.

The Table of my ſecond Station.

	Deg.
The Caſtle.	15
The Village.	25
The City.	40
The Eaſtern Head of the Bay.	50
The Weſtern Head of the Bay.	55
The Fort within Land.	80.

With theſe Tables I repair to a Paper, Parchment, *&c.* and by the former Rules draw the Figure following.



with your Eye, viewing round about, ſome other lofty place, from whence you may behold again all theſe places, for that ſhall be your ſecond Station, and turning thereunto the Index of your Inſtrument, note what degree it toucheth; this done, remove your Inſtrument thither, and place it in all reſpects as 'twas before, and turning the Diameter or Index of your Inſtrument to every place, eſpying through the Sight all ſuch marks as you ſaw before, noting again the degrees cut, or Angles of poſition, writing the names of every place, and its degree by it; ſo have you a Table alſo of your ſecond Station; with theſe Tables you ſhall reſort to ſome plain ſmooth ſuperficies of Board, Parchment, Paper, or ſuch like, and thereon deſcribe a large Circle, divide it into 360 degrees, like to the Circle of your Inſtrument; then from the Centre thereof to every degree noted in your firſt Table, extend ſtreight lines, writing upon every one of them the name of his place; and upon that line that repreſents your ſecond Station fix one foot of your Compaſſes, opening the other at pleaſure, and draw another Circle, and divide it alſo into 360 degrees, and from the Center thereof extend right lines to every degree noted in your ſecond Table, writing as before upon every one of them the name of their places or marks; finally, you ſhall note diligently the concourſe or croſſing of every two like lines, making thereon

a

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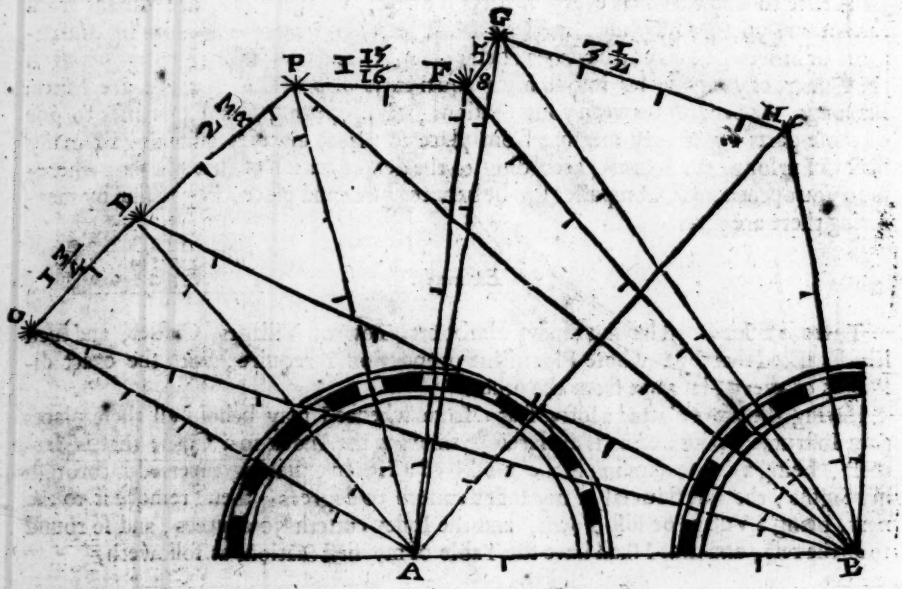
	Deg.
The Caſtle.	30
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This done, I behold another Hill or high place; from whence I may in like manner view all thoſe places, and turning my Index thereunto, I find the Line fiducial lying upon 180 Degrees; then carrying my Inſtrument thither, and placing it in all points there, as it was at the firſt Station, I turn my Index again to my firſt Mark or Caſtle, and find it to cut in 15 Degrees, at the ſecond 25, *&c.* as you may ſee in this ſecond Table.

The Table of my ſecond Station.

	Deg.
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The Village.	25
The City.	40
The Eaſtern Head of the Bay.	50
The Weſtern Head of the Bay.	55
The Fort within Land.	80.

With theſe Tables I repair to a Paper, Parchment, *&c.* and by the former Rules draw the Figure following.



Having thus compleated your Plot, and found the diſtance between A and B to be 5 miles, make a Scale according to that diſtance, divide it into miles and parts, and with it you may meaſure your diſtance from place to place, or the diſtance from any of your Stations to each place, according as you have occaſion.

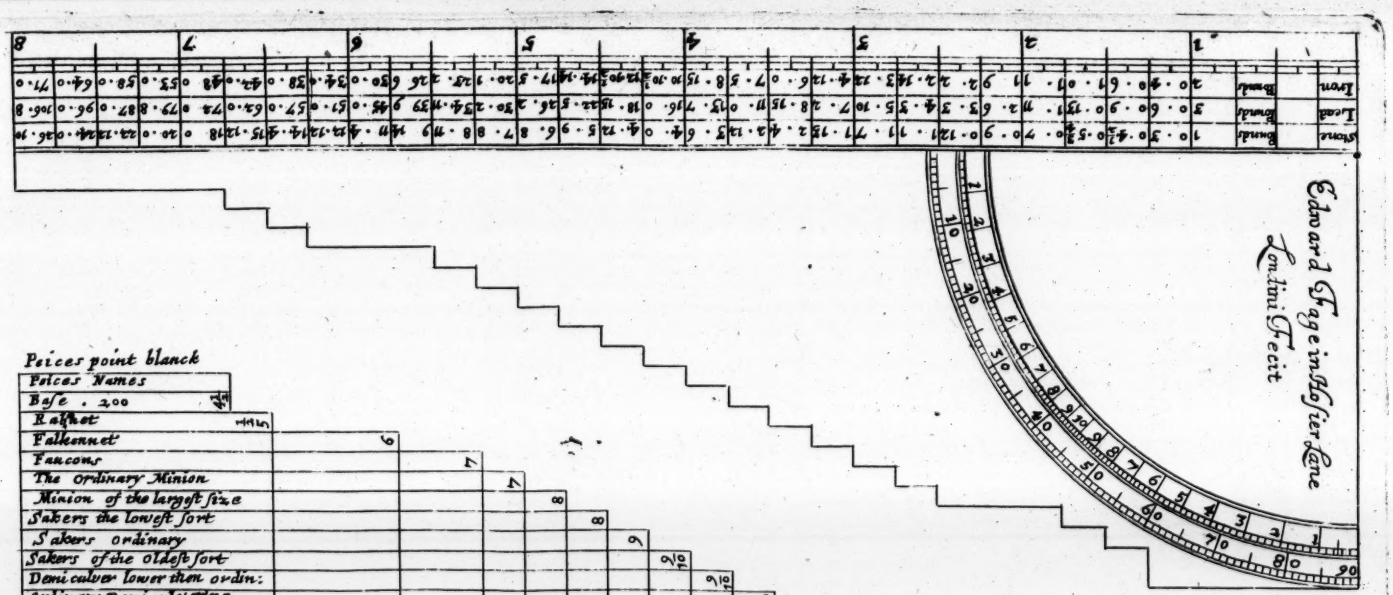
Thus paſſing or changing your Station, you may make ſeveral Plots, containing the true proportion and diſtance of Towns, Villages, Ports, Roads, Hills, Rivers, and all other notable places throughout a whole Realm.

Thus I ſuppoſe we have writ all ſuch propoſitions of meaſuring of heights, diſtances, and profundities, *&c.* as may be neceſſary to our work. We will next come to the more Practick part, of mannaging a Piece of Ordnance to do the beſt Service.

CHAP. XIV.

The Deſcription and uſe of the Gunners Scale.

THis Scale is made according to the Diameter of our *Engliſh* Ordnance, not above 8 inches long, being the Diameter of a Cannon Royal; they are generally made of Box, Pear-tree, or Braſs, any well ſeaſoned Wood that will not warp may ſerve: Upon one ſide I have ſet the names of all ſorts of Ordnance; and in the Angle of meeting with the names, is the Angle at the Bore; and between that and the next leſs Diameter, is the common length of ſuch a Piece; and upon the ſtep of bredth is the number of paces theſe Pieces ſhoot point blank; and right in the Angle of meeting, betwixt the two Diameters, with the Angle of meeting with the names, is firſt the weight of the Gun, the breadth of the Ladle, the length, weight of the Charge of Powder, the Diameter of the Shot, weight of the Shot, and a line of inches, and tenth parts of an inch. The Backſide is alſo divided into inches and quarters of inches, and over them is ſhewed the weight of every Iron Shot anſwerable to thoſe inches, with the weight



Peices point blanck

Peices Names																				
Base . 200	4½																			
Rafhet	3½																			
Falkennet		6																		
Faucons			7																	
The Ordinary Minion				7																
Minion of the largst size					8															
Sakers the lowest sort						8														
Sakers ordinary							9													
Sakers of the oldest sort								9 2/10												
Demiculver lower then ordin:									9 10											
Ordinary Demiculvering										10										
The oldest sort of Demiculver											10 12 15									
Culvering of the least size												12								
Ordinary whole Culvering													12							
Culvering of largest size														12 12 15						
Lowest Demicannon																12 12	17			
Ordinary Demicannon																		17	12	
Demicañon of great size																				
Weight of the Gun	300	400	750	880	1000	1400	1500	1800	2000	2700	3000	4000	4500	4800	5400	5600	6000	Cannon Royall 8000.		
Breadth of the ladle	4.1	7.4	8.4	8.4	9.0	9.6	10.4	11.0	12.0	12.6	13.4	14.2	16.0	16.0	20.0	22.0	22.6	24.0		
Length of the ladle	2.4	4.0	4.4	5.0	5.0	6.4	6.6	7.2	8.0	8.0	8.4	9.0	9.4	10.0	11.4	12.0	12.0	14.6		
Weight of the powder	0.14	1.4	2.4	2.8	3.4	3.6	4.0	5.0	6.4	7.4	8.8	10.0	11.6	11.8	14.0	17.8	18.0	32.8		
Diameter of the shot	1.3	2.2	2.5	2.7	3.0	3.2	3.4	3.6	4.0	4.2	4.4	4.6	5.0	5.2	6.0	6.1	6.5	7.4		
Weight of the shot	0.8	1.5	2.8	3.4	3.12	4 12	6.0	7.5	9.0	10.11	12.11	15.0	17.5	20.0	30.0	30.0	36.0	58.0		
	B.R	F.1	F	0.M	M.L	S.L	S.0	S.0 2	D.C.0	or D.C	D.C	C L	0. C	C. C	L. D. C	0.D.C	D.C.C	C.R.		
	1	2		3		4				5			6			7		8		

John . . 171.

weight of the like Bullet in Lead and Stone; each being diſtinguiſhed. You may alſo if you pleaſe have upon this ſide the Gunners Quadrant, and ſuch other things as you ſhall think fit, as you may ſee in this Figure following, where all things are diſtinguiſhed by their Names, and need no more Explanation.

You will obſerve by this Inſtrument, that the Ladle is but 3 Diameters of the Shot in length, and $\frac{1}{3}$ part of the Circumference, from the Cannon to the whole Culvering, and the charge of Powder will be found to be about 2 Diameters of the Piece; from the Culvering to the Minion, the Charge may fill 2 Diameters and a half; and from the Minion to the Baſe 3 Diameters; but of this matter we have ſpoke at large in the firſt part of this Book; but there having left out the Table of Periors and Drakes, I thought good here to inſert it.

A neceſſary Table of Periors and Drakes proportioned.

Names of Pieces.	Height of the bore in inches.	Length in Diameter.	Weight in met.pound.	Weight of Powder.	Length of the Ladle.
Canon Perior.	9. 10. 12.	8	3500	3, $3\frac{1}{4}$	3
D. Canon Drake.	$6\frac{1}{2}$	16	3000	9 *pound.*	$4\frac{1}{2}$
Culvering Drake.	$5\frac{1}{2}$	16	2000	5	$4\frac{1}{2}$
D. Cul. Drake.	$4\frac{1}{2}$	16	1500	$3\frac{1}{2}$	$4\frac{1}{2}$
Saker Drake.	$3\frac{1}{2}$	18	1200	2	$4\frac{1}{2}$

CHAP. XV.

How to make a true Diſpart of any true bored Piece of Ordnance.

KNow firſt, that to diſpart a Piece of Ordnance, is no otherwiſe than to bring the Diameter at Muzzle to be equal to the Diameter at the Baſe Ring; in true founded Ordnance, half of the Diameter of the Cylender is the diſpart; but more generally it may be done thus, Gird the Piece round about the Britch with a thred, after do the like by the Muzzle Ring, lay theſe two ſtrings ſtreight upon a Table at length, and make two marks for the length of each ſtring; divide the diſtance between each of theſe two marks into 22 equal parts with your Compaſſes, and 7 of them are their Diameters; then meaſure how much each Diameter is in length, and ſubſtract one Diameter from the other, then take the juſt half of the difference, and that is the true diſpart of your Piece in inches, and part of an inch.

But theſe Diameters are better and more artificially taken with a pair of Crallipars, as we have ſhewed before in taking the Diameter of a Shot, and then meaſured upon your Scale of inches and parts, will give you the true Diameters of the Piece both at Britch and Muzzle, with which work as above.

Alſo you may find the true diſpart of a Piece thus; Put a ſmall Wyer or priming Iron in at the Touch-hole of the Piece to the bottom of the Concave; then mind what part of that Iron is even with the Baſe Ring, and make a mark there; then take it out and apply it to the Muzzle, and place it upon the lower edge of the Concave of

the Piece as upright as you can, and mind what part of the Iron or Wyer is even with the upper part of the Muzzle Ring, and there make a mark; for the difference between these two marks, is the true dispart of the Piece: or after you have placed your Iron upon the Muzzle as before, cause a dispart to be raised so high as that mark which was made upon the Iron when 'twas put down the Touch-hole.

If from the top of the dispart a fine thread or line be carried to the Muzzle Ring, you will see how high you may make a dispart at the Trunions.

Or thus a dispart may be made at the Trunions; lay a peece of soft Wax upon the Trunions, and let one raise it high, or depress it, until that the Metal at the top of the Base Ring, the Wax between the Trunions, and the dispart of the Muzzle, be all three of one height precisely; but the former way with a thread is more exact.

A Piece of Ordnance may be disparted thus; take two sticks (each of them must be longer than the Piece) and also make a Plummet of Lead to hang in a small thread made fast to one end of the stick, which lay cross the top of the Base Ring, to and fro, until the Plummet descending from the end thereof, may just touch the side of the Metal of the said Ring; then keeping fast the stick in that place, hang your Plummet down by the other side of the stick, until it on the other side just touch the Metal of the Base Ring; when you have done, cut off the stick just in that place by which the Plummet descended, perpendicularly, and this length is the just Diameter of the Base Ring; after this manner you must proceed to take the Diameter at the Muzzle. Then lastly, set these two sticks together even at one end, and mark their difference in length or height; for just half of that difference is the dispart of that Piece.

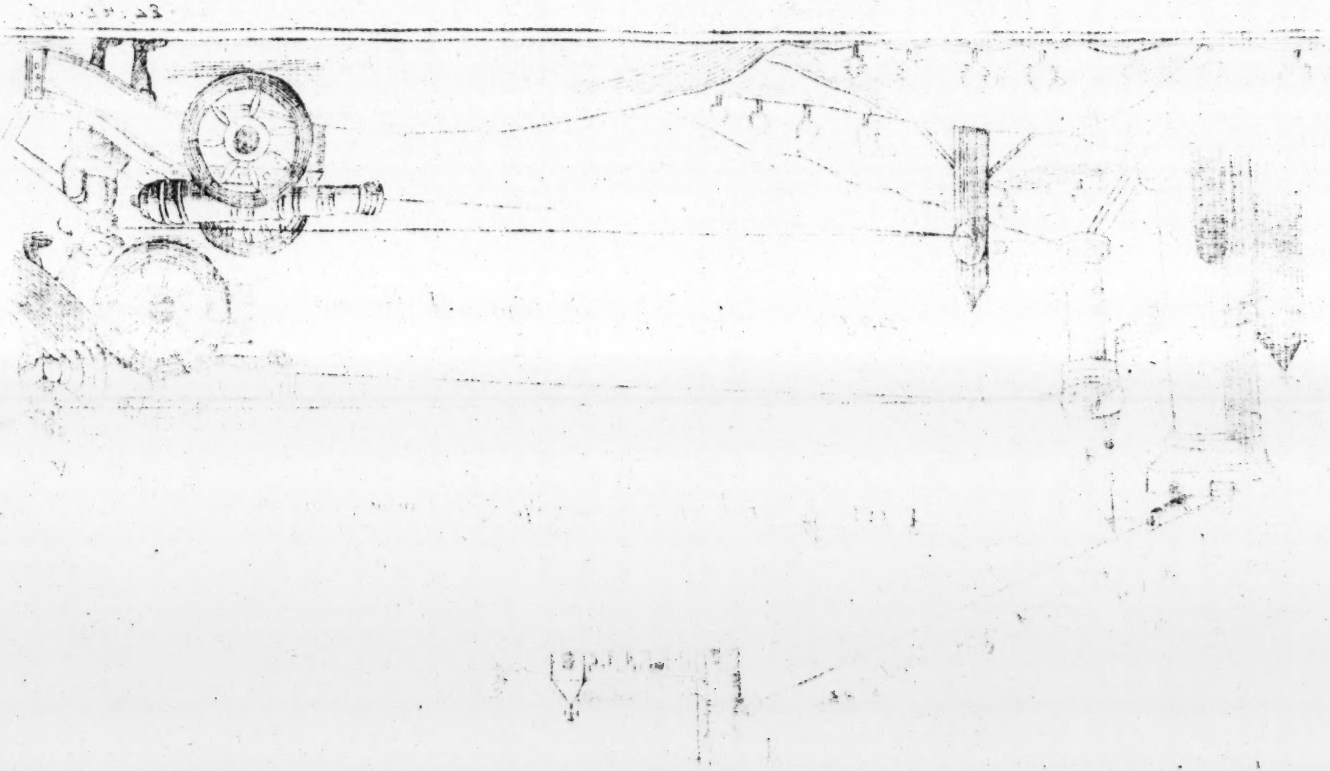
I would advise all Sea Gunners upon some occasions to use Disparts between the Trunions of their Pieces, made of a just height, on purpose to serve that place, by the method we have even now prescribed, and let them be tyed about the Piece with a twine, because else at every Shot they will be to seek, when upon a suddain they should use them, and they will much avail and stand them in great stead. I could express other wayes, only I think these sufficient.

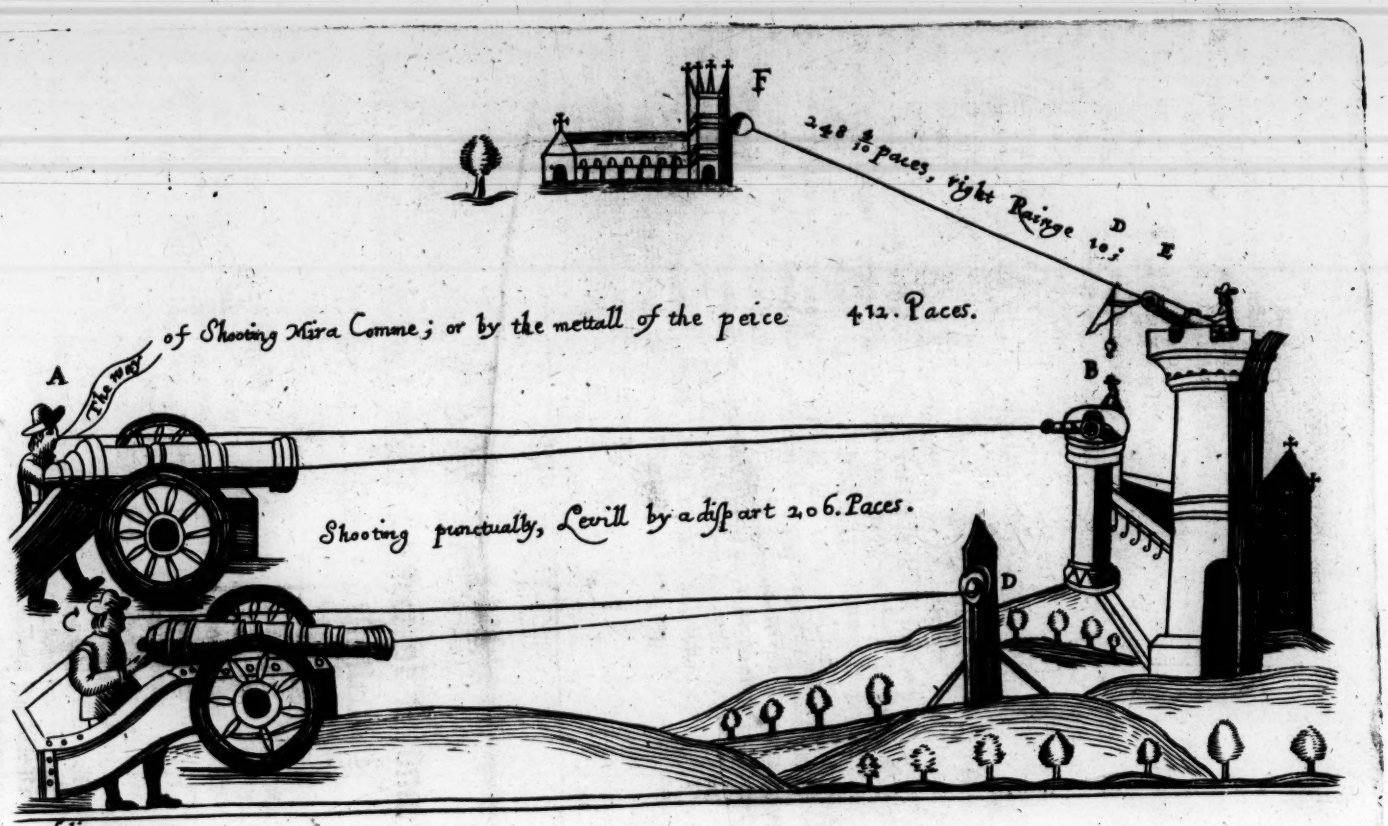
CHAP. XVI.

How to give Level with a Piece of Ordnance to make a Shot at any Mark assigned.

SEt your dispart on the Muzzle Ring, just over the Center of the mouth of the Piece, which you may best do by putting a stick cross the bore, and dividing it into two equal parts; then with a Plumb line hanging over the mouth of the Piece, being guided by the divided stick, you shall have good aim where to set your Dispart; this being done, go to the Base Ring, if the Piece be true bored, then find which is the highest part, and middle of that Ring; but if the Piece be not true bored, then find which part of the Base Ring is just over the Cylender, and take that for your true line: when you have found out the dispart, and placed it, and also found what point in the Base Ring is to answer to it, then make some very small mark on the Base Ring in that place, hold your head about two foot from the Base Ring, and there you may best observe, as the Piece is traversing, when you are in a direct line with the mark; this done, give one of your men order to raise and fall the Piece with his Hand-spike as you shall appoint him, until you can, holding your head two foot from the Britch of the Piece, with your eye perceive the mark at the Base Ring, and the top of the dispart in a direct line with the mark you must shoot at; at that instant stop the motion of the Piece with a Coyn, that it may remain as you have directed it; then Prime your Piece, and give fire.

Before




F
248 4/10 Paces, right Rainge
D
E
of Shooting Mira Comne; or by the mettall of the peice 412. Paces.
A
The way
B
Shooting punctually, Levill by a disp art 206. Paces.
C
D

folio 72: 73.

Before you place your Diſpart, you are to take notice whether the ground be Level whereon the Wheels of the Gun ſtand, or if they be not one higher than the other, and if the Trunions ſtand juſt over the Axeltree of the Wheels or no; whether one Trunion lye higher on the Carriage than the other: whether the Gun be truely placed in the Carriage or not; that is, that it be not nearer one ſide than the other: whether the Carriage be truly made according to the direction we have already preſcribed in the firſt part; whether the Axeltree be placed juſt croſs the Carriage or not.

CHAP. XVII.

How, if a Shot do carry to the right or to the left, under or over the mark, by reaſon of ſome known fault, to amend it in making the next Shot.

After you have made one Shot, and find the Piece carry juſt over the mark, then do all that has been taught again, and when your Piece lyes directly againſt the mark, obſerve how much the laſt ſtroak of the Shot is above the mark, ſo much longer make your diſpart, that the top of it may be juſt ſeen from the Britch of the Piece, in a direct line with the ſtroke of the Shot; when it is of this length, then level your Piece with this new diſpart to the aſſigned mark, Give fire, and without doubt it will ſtrike the ſame.

If the firſt Shot ſtrike under the mark, then bring the Piece in all points as before to paſs, mark how much of the diſpart is over the ſtroke of the Shot, and cut it juſt ſo ſhort, as being at the Britch you may diſcern the top of it, with the mark on the Baſe Ring and ſtroke of the Shot in a juſt right line, and when you perceive it is of ſuch a length, level the Piece to the aſſigned mark, as at the firſt, then Prime and Give fire.

If the firſt Shot ſtrike on the right hand of the mark, to mend it you muſt level the Piece as formerly; you ſtanding behind the Britch of the Piece, obſerve the ſtroke of the Shot over the diſpart, and that part of the Baſe Ring as you at that inſtant look over in a right line towards the diſpart, and the ſtroke of the Shot, ſet up in that place a Pin with a little ſoft Wax on the Baſe Ring; ſo this Pin will be in a right line with the diſpart and ſtroke of the Shot: This being done, level your Piece to the mark aſſigned by this Pin and the diſpart, and without queſtion you will make a fair Shot; for when you level by the Metal of the Baſe Ring where the Pin is placed, and the mark of the Piece ſtanding at that direction, look over the top of the diſpart from the notch in the Baſe Ring, and you ſhall find it to lye juſt ſo much to the left, as the former Shot ſtruck to the right, from the aſſigned mark, which ſhould in all likelyhood now ſtrike the mark.

But if a Shot be both too wide and too low, then you muſt uſe both the directions above taught, to make the next Shot: firſt regulate the diſpart by cutting it ſhorter, according as the Shots mark is lower than the aſſigned mark; when this is done, then proceed to my directions to mend ſhooting wide, and theſe things performed with care and diligence, cannot chooſe but mend a bad Shot.

CHAP. XVIII.

Of shooting at Random at a Mark beyond the right line of the Pieces reach, or right Range of a Shot; and the way of framing a Table of Randoms, by help of the Gunners Quadrant.

FOr the effecting of this matter, we must have a Quadrant with a Thread and Plummet (which is described in the first Chapter of this second Section) to one side of this Quadrant; so that one end of the Ruler may go into the Cavity of the Piece, and let a Piece of Lead be fastned to the end of the Rule, to make it lye close to the bottom of the Metal within, the Quadrant hanging without, and the Plumb-line swaying or hanging down from the Center of the Quadrant, perpendicular to the Horizontal line; for the *Quadrant* being thus placed, you may mount a Piece to what degree you shall find fit to shoot by.

Now every one that will learn to shoot at Random, must draw his Piece on a level ground, where first shooting level, he must observe that distance in feet or paces, then mount his Piece to one degree, and mark where that shall graze; thus finding the distance of every degree from the level to the tenth degree, by these distances make a Table, to which annex the degrees against the distance; by which Table you may (using the Art of Proportions) find how far another Piece will convey her Shot from degree to degree, and in Loading your Piece for this work you must have your Powder exactly weighed, and likewise the Wad, and let the Piece cool of it self, and this you must do every time; and if the Piece be mounted, there needs no Wad after the Shot; also you must have a special care of the strength of the Powder, and let the Powder equally, and with the same force and strength be pressed home, as near as possible you may.

CHAP. XIX.

An effectual Way to make a Shot out of a Piece of Ordnance at Random.

HE that intends to be expert at these things, ought principally to endeavour, at one time or another, to obtain so much liberty of his Superior Commanders, as to make two, three, or more Shot with the Piece he chooseth, or intends for most Service; then must he measure the distance from the Platform to the first graze of the Shot; and must apply it to the Table, which I have here inserted, being the experience of such as have been knowing Gunners. But first I shall set down Mr. *Nye* of *Worcester*'s Experiment, not as he is Mathematician, as he writes himself (which Title none of our Learned Mathematicians of *England* do assume) but as he was a Practical Gunner, and made these several experiments upon four several degrees of Mounture, *viz.* 1 deg. 5 deg. 7 deg. 10 deg. from thence was found these Randoms.

At

At 1 degree, the Shot did light from the Piece or place of ſtanding 225 paces.
At 5 degrees, the Random was 416 paces.
At 7 degrees, the Random was 505 paces.
At 10 degrees the Random was 630 paces.

And by theſe Experiments a Table may be framed according to this Rule. As the known degree of Mounture, is to the number of paces the Piece carries; ſo is the number of degrees propoſed, to the diſtance required.

The uſe of this Table will plainly appear in one onely Example.

A Table of Randoms.

Degrees.	Paces.
0	206
1	225
2	274
3	323
4	370
5	416
6	461
7	505
8	548
9	589
10	630

Suppoſe you make tryal of your Piece of Ordnance, according to the method preſcribed in the laſt Chapter, and find that at 6 degrees of Random upon a level ground, the Shot is conveyed 619 paces, and you are to ply your Piece againſt a place which lyes beyond the point blank, the diſtance being 498 paces, to know the degree the Piece muſt be elevated too, do thus; in this Table of Randoms againſt 6 degrees, there is 461 paces; then ſay as 619 paces is to 461, ſo is 498 to 375; which number, or the neareſt to being ſought, in this Table is 370, and ſtands againſt 4 degrees, but becauſe it is not exactly the ſame number, you muſt find out the part of a degree or minute, by a Table of proportional parts; but if the mark you ſhoot at be lower or higher than your Platformer, then you muſt add or ſubſtract ſo many degrees or minutes from the degrees and minutes found, and the remainder is the degree you ought to mount your Piece to.

Now that we may be underſtood well, we muſt know that there are two ſorts of Ranges or Motions of a Shot, of which you may ſee more in Chap. 20. the one is called the Right Range, and the other is termed the Curved or Crooked Range, and theſe two there termed a Compound Range, is called the Dead Range; that is to ſay, the whole diſtance from your Platform from whence the Shot was made, to the place where the Bullet firſt grazes; yet the perpendicular deſcending of the Bullet is alſo called the Natural motion, as you may ſee by the figure hereafter placed. Captain *Hexham* in his Book of Gunnery, ſhews how by finding out the Random of a Cannon for the firſt degree of Mounture to find the Random for every degree to 45 degrees, which is the utmoſt Random, after this manner; Firſt, find out how many paces the Cannon will ſhoot, being laid level by the Metal (which he accounts for one degree of Mounture) divide this diſtance by 50, then multiply the Quotient by 11, and that will bring out the number of the greateſt digreſſion or difference between Range and Range, which being divided by 44, the Quotient will ſhew the number of paces which the Bullet will looſe in the other Ranges from degree to degree. *Example.* A Battering Cannon being laid by the Metal, will ſhoot his Bullet (as he ſaith) 1000 ordinary paces, two foot and a half to each pace; which being divided by 50, the Quotient will be 20, which multiplyed by 11, is 220 paces, which is the number of the next digreſſion made in the ſecond degree: which 220 divide by 44, the number of the remaining degrees yields 5, which is the number of paces to be diminiſhed in each degree; and by this Rule this Table is framed.

A Table of Randoms to 45 Degrees, accounting 2 Foot ½ to the Pace.

The Degrees of Mounture.	Paces	diff.	The Degrees of Mounture.	Paces	diff.
0	0775	225	23	4685	110
1	1000	220	24	4795	105
2	1220	215	25	4900	100
3	1435	210	26	5000	95
4	1645	205	27	5095	90
5	1850	200	28	5185	85
6	2050	195	29	5270	80
7	2245	190	30	5350	75
8	2435	185	31	5425	70
9	2620	180	32	5595	65
10	2800	175	33	5560	60
11	2975	170	34	5620	55
12	3145	165	35	5675	50
13	3310	160	36	5725	45
14	3470	155	37	5770	40
15	3625	150	38	5810	35
16	3775	145	39	5845	30
17	3920	140	40	5875	25
18	4060	135	41	5900	20
19	4595	130	42	5920	15
20	4325	125	43	5935	10
21	4450	120	44	5945	5
22	4570	115	45	5950	

But this Table of *Alexander Bianco* for all ſorts of Ordnance, I do account as one of the beſt.

A Table of Randoms for the ſix points of the Gunners Quadrant.

	1	2	3	4	5	6
Faulconet.	375	637	795	885	892	900
Faulcon.	550	935	1166	1254	1309	1320
Minion.	450	765	954	1026	1071	1080
Saker.	625	1062	1325	1425	1487	1500
D. Culvering.	725	1232	1537	1653	1725	1740
Culvering.	750	1275	1590	1710	1785	1800
Demi-Canon.	625	1062	1325	1425	1487	1500
Canon of 7.	675	1147	1431	1489	1606	1620
Double Canon.	750	1275	1660	1710	1785	1800

The uſe of this Table is thus; having reſolved upon what point of Mounture, look in this Table for the name of the *Piece*, and right under that point againſt the name of the *Piece*, that is in the common Angle, you ſhall find the number of paces of her Random ſought.

CHAP.

CHAP. XX.

How to find the right Range of any Shot Discharged out of any Piece, for every Elevation by any one right or dead Range given for the Piece assigned.

THe right Range of every Piece being discharged in a level, or parallel to the Horizon, is allowed by some not to exceed 185 paces, that is 5 foot to a pace, yet some reckon much more, but then they account ordinary steps or paces of two foot and a half; and Batteries made with such Pieces are usally made at 100 or 120 such paces, at which distance they do the best execution.

The utmost Random likewise of any Piece that is from the Platform to the first graze of the Bullet, I find by some to be about ten times the distance of the right Range; and accordingly I have so set it down in the Table.

As for the Ranges to the other degrees and points of the *Quadrant*, I find these Tables in Good Authors.

A TABLE OF

The Degrees of the Pieces Mounture.	The Right Range in Paces, 5 Foot to a Pace.	The Degrees of Mounture.	The Paces of the Random, 5 Foot to a Pace.
0	192	0	192
1	209	1	298
2	227	2	404
3	244	3	510
4	261	4	610
5	278	5	722
6	285	6	828
7	302	7	934
8	320	8	1044
9	337	9	1129
10	354	10	1214
20	454	20	1917
30	693	30	2185
40	855	40	2289
50	1000	50	2283
60	1140	60	1792
70	1220	70	1214
80	1300	80	1000
90	1350	90	

This Table is rather proportional than real, and doth best agree with greater Ordnance; but by help of it, working by the Rule of proportion, you may know the Random of any Piece of Ordnance; by first (as we have said before) making one Shot, and measuring from your Platform that distance. You may make a Table for your Piece thus,

Suppose a Saker being mounted to 5 degrees, shoot the Bullet 416 paces, how far will it shoot being mounted 10 degrees?

As 722 the Tabular distance for 5 degrees of Mounture, is to 416 paces the distance found,

So is the Tabular distance for 10 degrees of Mounture, 1214. to the distance required, which will be found to be 699, 5 paces.

Now if you desire to know how much of the Horizontal line, is contained directly under the right line of any Shot, called the right Range, made out of any Piece at any elevation.

First, know that in plain Triangles, the violent motion or right line of a Shot is supposed to be the Hypothenusal, the Angle of Mounture to be the Angle at Base; these are given, and the Horizontal line is the Base which is to be found; there the proportion will run thus;

As the Radius 90 deg. is to the number of paces in a right Range;
So is the Sine Complement of the Angle of Mounture, to the Horizontal Base, or the right line which lyes parallel to the Horizon under the way of the Shot.

CHAP. XXI.

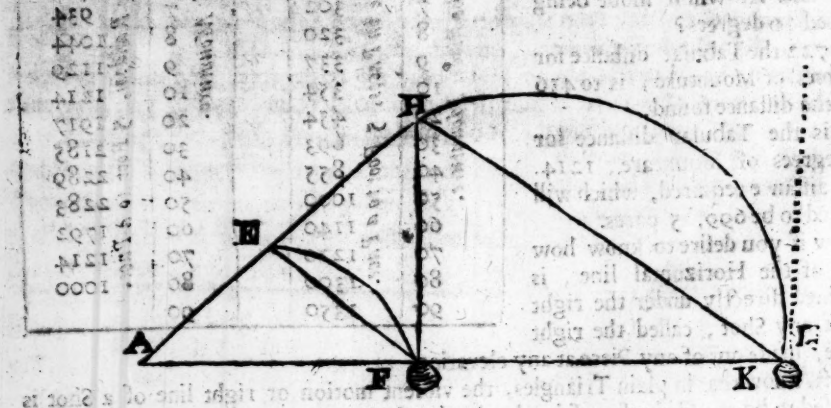
Of the violent, crooked, and natural motion or way of a Shot, from the time he is discharged, until it is descended.

BY the third and fourth propositions of the second Book of *Tartaglia*, his *Nova Scientia*, he sheweth that every body equally heavy, as a Shot in the end of the violent motion thereof, being discharged out of a Piece of Ordnance, so it be not right up or right down, the curved Range shall joyn with the right Range, and to the natural course and motion betwixt them both, which distinct motions you may see in the last foregoing figure.

In the 17 proposition of the same Book, he proveth that every Shot equally heavy, great or little, equally elevated above the Horizon, or equally oblique or level directed, are among themselves like, and proportional in their distance, as the figure following sheweth, as A E F is like and proportional in right and crooked Ranges unto H I, and in their distances or dead Ranges A F unto A I.

And in his 4th and 6th propositions of the same Book, he proveth that every Shot made upon the level hath the mixt or crooked Range thereof equal to the Arch of a *Quadrant* 90 degrees, and if it be made upon an elevation above the level, that then it will make the crooked Range to be more than a *Quadrant*: And if that be made imbased under the level, that then the crooked Range thereof will be a *Quadrant*.

And in his 9th proposition of the same Book, he shews, that if one Piece be Shot off twice, the one level, and the other at the best of her Random at 42 ½ deg. Mounture, that the right Range of the length is but the ⅔ of the dead range of the best Random. He that desires a further Demonstration of these Propositions, may peruse his said second Book *de Nova Scientia*.

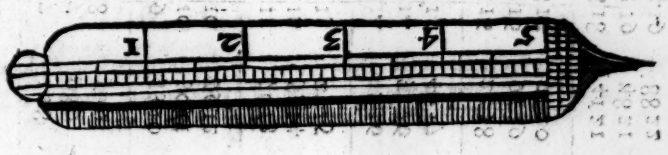


CHAP.

CHAP. XXII.

The making of a Gunners Rule, which will serve for the elevation of a Piece, which is sometimes better than a Quadrant; and the dividing it into degrees by help of a Table, fitting it for any Piece from 5 foot to 14 foot long.

BEcauſe the *Quadrant* cannot be conveniently uſed at all times, eſpecially when the wind blows hard, and, being near the Enemies Guns, the Plumb-line is too long before it ſtands ſtill; to remedy this, the Gunners Rule was invented, the figure hereof is as followeth; it muſt be 12 or 14 inches long, according as the Gun will require, it muſt have a long ſlit down the middle thereof like the Eye-Vane of a *Quadrant* or back Staff, the head thereof make circular or a little hollow, as you ſee in the figure the Inſtrument is deſcribed ſtanding, at 'tis to be placed upon the Britch of a Piece of Ordnance; in the middle of the ſmall narrow ſlit you muſt place a Lute ſtring or a well twiſted Silk with a Bead running upon the ſame to be ſet to any number of inches and parts, or to ſuch a degree of the *Quadrant*, as you muſt mount your Gun unto; and on the one ſide of the ſlit you muſt place a diviſion of inches, and let every inch be divided into 10 parts, and then it will ſerve for all ſorts of Guns; but if it be for a particular Gun, then on the other ſide you may place the degrees and parts, when you ſhall find by the length of your Piece, how many inches and parts of an inch goes to a degree; but to uſe it with all ſorts of Ordnance, let it only be divided into inches and parts.



To fit this Rule for one Gun only, here is the Rule for the decimation of the degrees; note, this Table hath 11 Columns, the firſt ſhews the length of the Piece in feet and half feet, the other 10 Columns in the head are 10 degrees, and under is inches and the 100 parts of an inch, from 1 degree to 10 degrees; and ſo you may take them out of the Table, and put them on your Ruler.

The len. of the Piece.	1 Degree.		2 Degrees.		3 Degrees.		4 Degrees.		5 Degrees.		6 Degrees.		7 Degrees.		8 Degrees.		9 Degrees.		10 Degr.
Feet and ½ Feet.	Inch.	100	Inch.	100	Inch.	100	Inch.	100	Inch.	100	Inch.	100	Inch.	100	Inch.	100	Inch.	100	Inch. 100
4 Foot long.	1	32		63		84		115		146		167		198		829		2510	28
5 Foot and half.	1	142		283		424		565		706		847		989		1230		2611	40
6 Foot long.	1	222		443		664		886		107		388		589		7811		812	29
6 Foot and half.	1	362		724		85		446		808		179		3310		8912		3513	63
7 Foot long.	1	472		944		415		887		358		819		3011		7713		2414	73
7 Foot and half.	1	583		144		716		287		859		419		9912		5514		1415	71
8 Foot long.	1	683		365		46		728		4010		811		7613		4115		1216	82
8 Foot and half.	1	793		585		377		1681		9510		7413		5314		2717		8118	92
9 Foot long.	1	893		795		687		589		4711		3715		1516		1217		8118	98
9 Foot and half.	2	004		006		008		010		012		014		216		3118		4120	4
10 Foot long.	2	104		206		308		409		3012		6114		7116		8418		5621	8
10 Foot and half.	2	214		416		618		819		8113		2815		4817		6819		8922	10
11 Foot long.	2	314		626		934		2413		5613		8813		1216		2518		8223	14
11 Foot and half.	2	424		847		269		6812		1014		5314		9116		3719		8024	21
12 Foot long.	2	535		067		596		1212		6515		2118		9217		5220		7825	33
12 Foot and half.	2	635		207		896		3513		1716		7819		4119		4121		4223	33
13 Foot long.	2	745		488		8210		5314		3917		4420		8121		4821		9224	40
13 Foot and half.	2	845		688		5311		3614		2717		1020		5122		8822		7225	42
14 Foot long.	2	955		908		8511		7317		6118		4820		2522		6523		6026	53

The use of this Table in graduating the Rule is very plain; for if your Piece of Ordnance be 8 foot long, and you would mount your Piece two degrees, seek for 8 foot under the title length of the Piece, and in the common Angle against the length of the Piece under two degrees you will find 3, 36, to make a degree; that is 3 inches and 36 parts of an inch, divided into 100 parts, and to this you may set your Bead.

The

The uſe of the graduated Rule is thus: having loaded your *Piece*, and brought your Piece of Ordnance in a right line with your mark, the diſpart being placed upon the Muzzle Ring, in like manner place your Rule upon the Baſe Ring, and let one ſtanding by hold it, for the foot of it let it be fitted round to the Gun; ſo you may be ſure to place it right, and you may eſtimate on its perpendicular well enough; now having before the diſtance to the mark you intend to ſhoot at, and admit you have found it to be 461 paces, and the firſt Shot you made for practice out of that Piece conveyed her Shot at two degrees of Mounture 274 paces; then by our former Rules and the Tables of Randoms, there I find 461 againſt 6 degrees, which is the degrees I muſt mount my Piece to reach 461 paces.

Then to find by this Table how many inches and hundred parts of an inch 6 degrees will require, look in the Table above, and find on the left hand in the firſt Column the length of the Piece, and juſt under the degrees (as is aforeſaid) you ſhall find the inches and parts of Mounture, to which ſet your Bead on your ſtring, that is in the ſight, to ſo many inches and parts as the Table gives; then mount the Piece higher or lower, until you bring the Bead to the top of the diſpart and mark, all in one line; ſtop then the Piece in ſuch a poſition with a Coyn, then prime and give fire.

If you will ſhoot by the Metal of the Piece without a diſpart, then ſubſtract the height of the diſpart out of the inches found by the Table, and to the remainder mount your Piece.

If you have no *Quadrant* nor a Ruler, and would make a good Shot, look in the Table, and find the length of the Piece and the inches that you ought to raiſe your Piece unto, then cut a peece of ſtick juſt of that length, and ſet it upon the Baſe Ring, and bring the top of that ſtick, the top of the diſpart, and the mark, all in a right line with your eye, and you will make as good a Shot as if you had a Rule and Bead, or *Quadrant*.

If you will have no diſpart, take your diſpart and meaſure it upon the aforeſaid ſtick at the Baſe Ring, and from it cut off the length of the diſpart, and the remainder uſe upon the Baſe Ring.

But if the Mounture ſhould be ſo ſmall that the inches of the diſpart ſhould be more than the inches anſwerable to the degrees of Mounture; then cut off from the diſpart ſo much as 'tis longer than the other, and place it upon the Muzzle Ring, and bring the upper part of the Baſe Ring, the diſpart, and mark, in a right line with your Eye, and you will this way make a level with a ſtick without Inſtrument, as well as if you had Ruler or *Quadrant*.

CHAP. XXIII.

How to make a Shot at the Enemies Light in a dark night, and to make at a Company of Horſemen or Footmen paſſing by, and alſo to make a good Shot at a Ship Sailing; and how a Shot lodged in a Piece, ſo that it will not be driven home to the Powder, may be ſhot out without hurt to the Piece.

TO ſhoot by night at the Enemies Lights, diſpart your Piece with a lighted and flaming Wax Candle, or with a lighted Piece of Match, that with your Eye you may bring the Baſe Ring, the fired Match on the Muzzle Ring, and the Enemies Light, in a right line, or mark; then give fire, and you will make a good Shot.

If you make a Shot at a Company of Horſe paſſing by, take a *Piece* that will reach the way the Horſe or Foot are coming in a right line, then let your Gun be ſo loaded with *Powder* as it may preſently take fire, and let your Shot be fit for your uſe; then take notice of ſome Hillock or ſome turning croſs way for the mark, and when the Enemy comes near to that way in a right line with your Gun, give fire; but for ſhooting at a Ship upon the River, you muſt put your *Piece* to ſome eminent mark on the other ſide of the River, and when the Head of the Ship ſhall begin to be between the *Piece* and the mark, then give fire.

But if by ſome miſchievous accident a Shot is lodged in the concavity of a *Piece*, and there ſticks, and will not go home to the *Powder*, or come out; then the Gunner, to ſave his *Piece* from breaking, muſt imbaſe the mouth of the *Piece*, or put it under the line of level, then put in at the Touch-hole fair warm water at ſeveral times, ſo that it may run out at Muzzle or Mouth of the *Piece*; and when all the Salt-*Peter* is waſhed from the *Powder*, which is known by the taſte of the Water, then let the Gunner clear the Touch-hole, and put in as much *Powder* as poſſible he can, and prime and give fire, and it will ſerve to draw out the Shot.

But when a Shot hath lain long in a *Piece* until he is grown ruſty, and ſo ſticks faſt, put ſtrong Vinegar warm into the mouth of the *Piece*, and with the Rammer ſtrike the Shot until it doth move; then put in Vinegar until it run clear through the *Powder* and Shot; prime as before, and give fire with good *Powder*, and if it do not run through after it hath ſtood three dayes, clear the Touch-hole, prime and give fire.

A man may alſo ſhoot farther than ordinary in one and the ſelf ſame *Piece*, if the Powder be gently driven home, and wadded accordingly; then the Shot being compaſſed with Paper, Leather, Oakam, or ſuch like, to fill cloſe to the *Powder* with a good Wadd, putting after it a Tampion of Cork, and with a Spunge moiſten it with Oyl, annoint the vacant Cylender, and ſo Barricado the *Piece* that it may not reverſe in the Diſcharge.

CHAP. XXIV.

A Diſcourſe by way of Dialogue between a General and Captain, concerning the Aſſaulting a Town or Work, &c.

General. HAving brought your Approaches near unto a Town or a Fortreſs, whether would you chooſe a Bulwark or a Curtain to be battered with your Ordnance?

Captain. A Town may be aſſaulted in divers places; ſometimes you aſſault one ſide, when as you make your Battery on another; ſometimes you chooſe a Bulwark, otherwhiles a Curtain to be battered, with this intention, to take in the Town as ſoon as poſſible may be. As for me, if I were to take in a great Town which is populous, I had rather chooſe to batter a *Curtain*, than a *Bulwark*, which hath a high catt, or mount upon it: eſpecially, ſeeing that in great Towns the Bulwarks lying one far from another, they do ſhow the skirt of the Curtain very open.

Gen. Why would you rather chooſe a Curtain than a Bulwark?

Capt. Becauſe your Bulwarks are alwayes ſtronger, and better fortified than your Curtain, and being it is the principal ſtrength of a place, and better furniſhed with *Platforms, Flanks, &c.* it will require more time, labour, and charge to batter, than your Curtain.

Gen.

Gen. But what General is ſo ill experienced, as to labour to batter a Curtain, having two ſtrong Bulwarks on both ſides of him, to flanker him when he is to put over his Gallery, and to give an aſſault upon the Curtain: peradventure for his labour and pains, he may be well beaten.

Capt. Soft (Good Sir,) Suppoſe that after a great deal of labour and pains you have battered a Bulwark, and falling up to the breach to aſſault it, you find it cut off, an Enemy lodged in it, muſt you not then begin to ſap forward again, to make a new battery? whereas on a Curtain there is not that means of cutting it off, as upon a large Bulwark.

Gen. Have you ever ſeen the experience of it?

Capt. *Yes Sir, the Prince of* Orange *took in the* Boſch *by a Bulwark, and alſo* Breda, *but* Maſtrick *was taken in by making a breach, and ſpringing of a mine, upon the Curtain between* Jonger *Port and a Bulwark*; howſoever the Town of *Cortes* upon the frontiers of *Franee*, was firſt battered by the *Arch-duke of Auſtria* upon the point of a Bulwark, near unto the very joynt of the Curtain, where a high and a ſtrong turret ſtood, which did annoy us much, ſo that we could not advance forward, but were conſtrained to leave off our approach on that ſide, and began to make a new Battery for a breach in a Curtain on the Field-ſide, where there lay a ſtrong Bulwark to defend it, which did our men a great deal of harm; but howſoever, with great difficulty and much ado, we took in the Town that way, by lodging our ſelves in the Curtain. Likewiſe the City of *Cambray* was battered, and taken in upon a Curtain, for all there were two ſtrong Bulwarks that flankered it, which if we had run our line upon a Bulwark, we ſhould not have forced it ſo ſoon; yea ſuch an occaſion might preſent it ſelf, that a General may be forced to batter both the one and the other, or to find out ſome ſecret way by undermining a wall, and blowing it up with powder.

Gen. This is for your great Towns; but what ſay you to a Caſtle, a Cittadel, or ſome narrow Fortreſs, how will you go to work to take in thoſe with the beſt advantage?

Capt. As for your Forts, and Caſtles, it is much better to batter them upon a mount or a Bulwark, than upon a Curtain: my reaſon is this, that in theſe your Bulwarks lying cloſe one by another, will flank one another with the greater force, and hide the Curtain much better to defend it, ſo that one cannot ſo eaſily force it, if the ſaid defenſes be not taken away.

Gen. Go to then; a Town then being to be battered, either upon a Curtain or a Bulwark, how many Pieces of Ordnance would you have to do it, and, how and in what manner would you place, and plant your Ordnance upon your batteries to make a good breach?

Capt. To effect this, I would have 18 Pieces of Canon and half Canon, *(for leſſer Pieces for Battery are now grown out of uſe.)*

Gen. Whether would you chooſe more whole Canon or half Canon?

Capt. To batter a place well either upon a ſtony or earthy wall, you may aſſure your ſelf, the more whole Cannon you have, the greater and the more ſufficient your breach will be: for your great battering Pieces do ſpoil and beat down any thing, which doth meet with their great force and violence: *Howſoever of late years experience hath taught at divers Seiges that your half Canon which are more portable, having good ſtore of them, will do the buſineſs aſwell as your whole Canon.*

Gen. But at what diſtance would you make your Batteries, for theſe 18 Pieces of Canon, and how near unto the place, which you intend to Batter.

Capt. I would counſel a General to approach as near unto that place as poſſible may be, and make his Batteries ſome two or three hundred paces one from another, and that if it were poſſible to advance covertly the Approach and ſap, even up to the Counter-ſcharfe, and very brink of the Moat, to prepare a way for his Gallery: not only to Batter that place being at hand with the greater force, but alſo to keep in, and hinder an Enemy from Sallying out upon the Beſiegers, to diſcover and diſmount their Ordnance in *Caſemates*, or if they have ſunk any in their Walls or Falſe-bray, and ſo to terrifie them, that they dare not ſtir out.

Gen. I am alſo of your opinion, and hold it for good, yet I fear this will not be ſo ſoon done, and is ſooner ſpoken, than executed, and that before you can bring your approach and ſap ſo far, it will coſt you warm blood, and a great many mens lives, if you have a ſtout Enemy within to deal withal, and one that is very Vigilant, and careful to ſtand upon his Guard, and his defence.

Capt. 'Tis true, this cannot be done without danger, and the loſs of men, but he that is fearful muſt ſtay at home, and not come into the Wars where there is neither place nor time, which doth free or exempt him from danger: yet the danger is not alwayes ſo great, eſpecially in ſuch places, where you have Earth enough to work with, to caſt up your ſapps, and to heighten and deepen your Approaches, which will ſhow you the way, for the more higher you find the ground in Approaching to the edge of the moat, the deeper Trenches you may make, and cover your ſelf by caſting up of blinds continually, to keep you from the ſight of the Beſieged; and it is better, when you have brought your approach as it were under them, than if you were 200 or 300 paces diſtant from them.

Gen. I pray you Good Sir, how would you plant, and divide theſe 18 Pieces of Canon?

Capt. I would make a great Battery with 8 of them to beat upon a right line, either upon a Curtain, or the point of a Bulwark (which the General ſhall find fitteſt) Two Batteries with each 3 Canon to play ſlope-wiſe from the great Battery; as the ninth plate and 28 and 29 figures ſhows, and two Batteries, with two half Canon a Piece, to play as it were croſs-wiſe upon the breach. And thus you ſee your 18 Pieces planted upon 5 Batteries, as you may obſerve in the 9th. Plate, and the two Figures of a Curtain and of a Bulwark following.

Gen. Good Sir tell me I pray you how many ſhot will theſe 18 Pieces of Canon make in 10 hours, and how much powder will they require.

Capt. In 10 hours they may make ſome 1500 ſhot, and will require a matter of 25000 pound weight of powder, that is 150 barrels full, each barrel containing 160 pound weight in it.

Gen. You make your account then that every Piece in the ſpace of 10 hours is to ſhoot 80 ſhot, that is 8 ſhot an hour for every Piece.

Capt. You may make 10 ſhot in an hour if you pleaſe, if your Pieces be renforced; but as for your ordinary Pieces, they have not metalline ſubſtance enough to bear it: conſidering alſo that after you have made 40 ſhot out of a Piece, it will be ſo heated, that it muſt have a cooling time, which muſt be at leaſt an hour, for otherwiſe your Piece being grown over hot, it may cauſe danger.

Gen. Methinks that 80 ſhot for a Piece in ſo long a time were too little, having often heard, that in that while, a Piece may well be ſhot off 130 times; can you give me your reſolution upon this?

Capt. I will tell you Sir what hapned once in the Iſland of *Bomble*, Anno 1599. we planted a Piece by a mill, by which we did annoy the Enemy very much, ſo that they were forced to make a Battery, and planted a whole Canon, and a demy-Canon upon it, ſeeking to diſmount ours. Now ſhooting with this Piece from four of the clock in the morning, till eleven toward noon, this Piece had a cooling time the ſpace of two hours, and about one of the clock we began to play with it again, and continued ſhooting with it till 4 a clock in the afternoon; but this Piece being not able to endure the force and heating of ſo many ſhot, we were conſtrained to leave off with it: and yet ceaſed not ſhooting with our other Pieces from another Battery by command from *Don Lewes de Valaſco*, General of our Ordnance, and ſhooting croſs-wiſe with ſome other of our Pieces, we put the Enemies two Pieces to ſilence in the ſpace of an hour; a Souldier of ours ſtanding by, was curious to keep a tally of the number of all the ſhot we made from the morning till four a clock in the afternoon, and ſhewed me 80 notches, which deducting the two hours cooling, our Piece planted at the Mill made 8 ſhot in an hour, which was as much as could be required of it.

Senior Diego Uffano *give your Tranſlator leave to interrupt you a little, and ſo to conclude this diſcourſe. If you remember at the Seige of* Oſtend, *which you mention of it in*

in your Chapters and Dialogues, you were without, and I was within the Town, that on the ſeventh of January, Anno 1602. Stilo Novo, *After Sir* Francis Vere *of famous memory (who defended and kept the Town againſt you) had deluded you with a* Parley, *only to gain time, and to make up our Canon and Sea-beaten works along the skirt of the old Town, his Highneſs the Archduke reſolved to aſſault us, and that morning began to batter* Sand-hill *and* Schotenburgh, *to make a breach for you againſt that night, with intent to Aſſault us (as you did) and to have entred the Town, and have put us all to the Sword, the Relation whereof you ſhall hear in the end of this Book. Now you had placed and planted your* 20 *Pieces of Cannon to batter them in this manner,* 8 *from your Battery at the foot of the* Downs, 8 *from a Battery on the right hand of the* Downs, 6 *from your pile Battery,* 6 *more which you had made upon the Sand, and as it were raiſed out of the Sea: the firſt ſhot upon the breach in a right line, and the other two ſlope-wiſe, as your two figures following do demonſtrate. Theſe* 20 *Pieces of Canon towards noon had a cooling time, for a matter of ſome* 2 *hours, juſt as you have ſaid; and afterwards you began to batter the breach and old Town again, till it was almoſt twilight, and then they cooled again, till you were ready to give us an aſſault; and before you fell on, as I do well remember, you ſhot off one of your Cannons with a hollow Bullet, which flew over the Town and made a great humming noiſe, as a warning Piece to the* Count of Bucquoy, *who lay on the Eaſt-ſide, that you were then ready to fall on, and that he ſhould do the like, this was your Signal. Now* General Vere *knowing well your intent, gave order to the Gentleman of our Ordnance who had the guard upon* Sand-hill, *that he ſhould keep a true Tally, and an account of all the ſhot you made that day, with your* 20 *Pieces of Cannon upon the breach and the old Town, which being caſt up, there were found to be made that day from morning till night* 2200 *ſhot, which was found to be an* 110 *ſhot for every Piece, and* 11 *ſhot an hour for every Piece, which is more than* 8; *but I verily believe your Pieces were renforced.* This by the way, and ſo I return again to your own Dialogue.

Gen. (Good Sir) I pray ſhow me how you would batter the point of a Bulwark (as the figure 28 following demonſtrates,) and give me ſome reaſons aſwel defenſive as offenſive.

Capt. I am willing to give your Lordſhip content, and ſay, If I were to batter the point of a *Bulwark* or a *Baſtion*, I would have the ſame number of battering Canon, and planted in the ſame form and manner as they were for the Curtain, and to ſhoot ſloap and croſs-wiſe alſo; and if your approaches were advanced ſo far, they ſhould be planted upon the very brink of the moat and upon the *Counterſcharfe*, I would plant 4 of them ſo, that they ſhould diſmount the Enemies Canon in their *Caſemates*, or any, if they had ſunk them in their *Falſebray*, which ſhould wait upon that occaſion.

Gen. I am of your mind, and prefer ſuch a battery before all others, who are of the opinion that they had rather chooſe a Curtain than a Bulwark to be battered.

Capt. You have heard my reaſons for that, and ſee the figures following traced out to you. But as for your *Bulwark* the *beſieged* may cut it off (as you may mark in the figures of *Retrenchments* and *Cuttings off* in the ſecond part of this book) for indeed it will be a hard matter to force an Enemy out of a Bulwark, who is reſolved to looſe it by peecemeal and degrees; and there is not ſo much danger in aſſaulting of a Curtain, which being once well battered and beaten down with your Ordnance, you have an eaſier way and entrance to fall on with your Troops of men, to enter the Town or Fortreſs; but for the defence which is made from your Flanking Bulwarks, or your Caſemates, you muſt make Batteries upon the brink of the moat againſt them, (as is ſaid) to diſmount the Enemies Pieces, and to flanker with your Ordnance the Parapets of the Bulworks to beat them about their ears, that the Bulworks may lye the more open to you, and I think this way is the leaſt danger.

Gen. But the Beſieged, their cuttings off, may they not be made aſwel upon a Curtain as upon a Bulwark.

Capt. No, for the Rampire being thinner, you have neither ſo much ground, nor the like accommodation in a Curtain as in a Bulwark; and indeed, a Governour

of a Town, or of a Fortreſs, if he were put to his choice, had rather to be aſſaulted on a Bulwark (than on a Curtain) by cutting it off into the form of a half moon, that he might make a new reſiſtance, and defend it with a leſs number of men. Beſides, in a Bulwark the Beſieged have this advantage over the Aſſailants, which is very dangerous for them, that they may make a Mine within the bowels of their Bulwark when an Enemy ſhall attempt to aſſault it, and thinking to enter the Breach and take the Town, they may be blown up into the Air by a Countermine; the like alſo may happen to the Beſieged, the Aſſailants ſpringing their Mine alſo in a Bulwark, when they think they ſtand upon their beſt defence.

Gen. May not the like be done alſo in a Curtain?

Capt. No, it will not take the like effect as in a Bulwark; for a Breach being once made in a Curtain, for as an Enemy may aſſault it at large, ſo they may bring a greater number of men to fight, to help to defend it; whereas in a Bulwark they are pen'd up and ſtraightned in a narrow place, which may be cut off, and will require a fewer number of men to defend it, whereas thoſe which are to force it, muſt be conſtrained to bring up a great many men to aſſault, who in an inſtant may be in danger of blowing up.

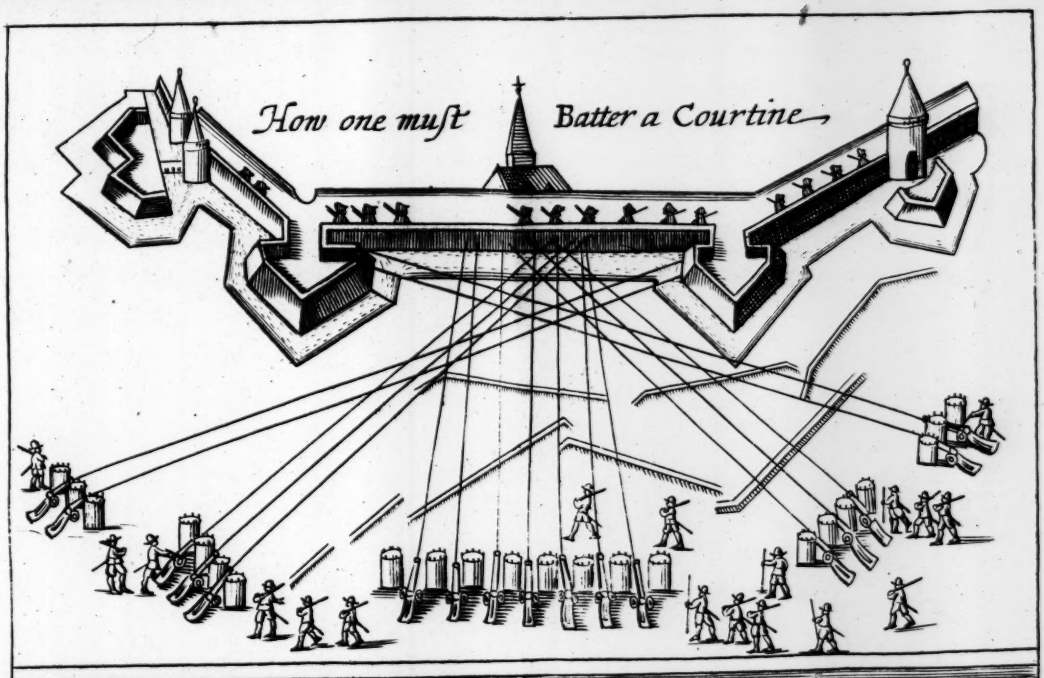
Gen. Your reaſons (Good Captain) are not to be ſlighted; but as for me, I hold it ſafer, to batter and aſſault the breach of a Bulwark, than of a Curtain. For though the beſieged may cut it off, and defend it with a fewer number of men, yet the Aſſaulters have this advantage over the Beſieged defendants, that they have more place and elbow room, and may find a leſs reſiſtance than in a Curtain, ſeeing that one may make as a great a breach in a Bulwark as in a Curtain, becauſe your Ordnance may beat it flat, and level with the ground; and chooſing rather a Bulwark: I will herewith conclude this diſcourſe, and now ſhew you the figures both of the one, and of the other in this following plate.

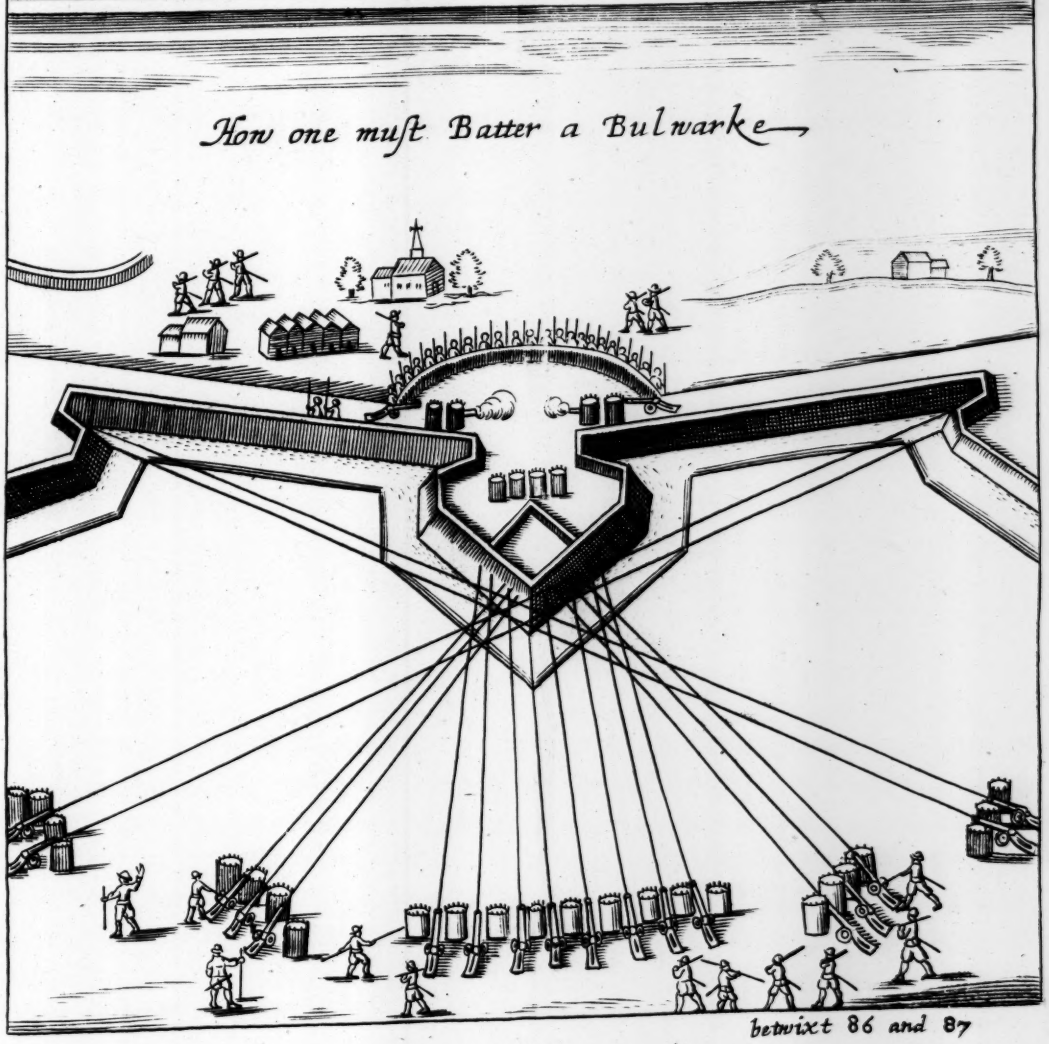
CHAP. XXV.

Containing the demonſtration of Morters, and the uſe of them.

YOur great and ſmall Morters, are not only ſerviceable in a War offenſive, by ſhooting and caſting of great Granadoes, as of 100, 150, 170 pound weight, and ſmaller of 40, and 50 pound; but alſo by caſting of Fire-balls, Stones, old Rubbidge, and Pieces of Iron, into Cities, Towns, and Fortreſſes; and may be uſed alſo defenſively, to be ſhot from Towns and Forts into any Enemies works, and approaches; eſpecially they are of ſingular uſe, when an Enemy hath covertly approached, and lodged himſelf under ſome Bulwark, Tower, or Turret, and is a beginning to undermine them; which if they do, you may plant one of theſe Morters at a reaſonable diſtance, on the inſide of your Wall, and ſhooting your Granado, as it were bolt upright into the air, by its natural fall it may light juſt into the Enemies works, and there with great violence breaking among them, it will make them cry, fly, and forſake the place; you may alſo fire them out of a place, by caſting good ſtore of Hand Granadoes down among them, and ſo annoy them, that the work will be too hot for them.

Two of theſe Morters are repreſented unto you, in the Plate and Figures following number. Now for the ſhooting a way of your great Granadoes or Fireballs, you muſt ever remember, but to take ¼ or ⅓ parts of fine Powder of the weight of your Granado





betwixt 86 and 87

Granado or thing which you ſhoot; but if you are to ſhoot away a Bullet without any Fire-works in it, or ſome maſſie ſtone, or ſuch like ſolid thing, then you muſt take but half the weight of it in fine Powder, which, having given fire to the Morter, will ſend it going merrily.

The uſe of them is not to ſhoot in a right line, as other Ordnance do, but in an oblique line, as you may ſee by the two Figures following, unleſs your Morter be mounted to 90 degrees, mounting them uſually above 45 degrees, namely to 60, 70, 80, and ſometimes more or leſs, as the diſtance and fall of your Granado or Shot ſhall require.

Having before ſhown you the making and uſe of the Quadrant, it remains now that I come to the charging and uſe of a Morter; now before you put in your Powder, it muſt be well ſponged and cleared, whether you charge it with looſe Powder, or Cartouch, turning the mouth almoſt bolt upright; the Powder being put into the Chamber, you muſt ſtop it with a Wadd either of Hay or Oakam, and after a Tampkin of ſome ſoft wood, and this with the Powder that was put in firſt, it muſt fill up the whole Chamber thereof, that there may be no vacuity between the Powder and the Wadd, or between the Wadd and the Shot; this done, the ſhot ſhall be put in at the mouth, with another Wadd after it; but you muſt have a care that your Morter be not much mounted, leſt your ſhot flyes out too ſoon, and the Wadd between the Tampkin and the ſhot will not only ſave the ſhot from the Tampkins breaking of it, but alſo is to avoid vacuities which may endanger the breaking of the Piece by ſecond expanſions.

Now then having reſolved of the premiſſes, touching your Piece, Shot, and Powder, as aboveſaid, and upon the diſtance and mounture of your mark, as the Rules and Tables following ſhall direct you, then for the bending and diſpoſing of it to the aſſigned mark; lay firſt a ſtraight Ruler upon the Mouth of your Morter, and upon it place a Quadrant (as you may ſee by the Figures) or ſome other Inſtrument croſs-wiſe, to ſet the Morter upright, for ſhuning of wide ſhooting, and then placing them fore-right to elevate it into the reſolved degree of Mounture, to avoid ſhort or overſhooting, accordingly as the Tables following will teach you; for having made one ſhot, you may thereby proportion the reſt, conſidering whether you are to ſhoot with or againſt the wind, or whether it blows towards the right or the left hand, whether weakly or ſtrongly, and ſo accordingly to give or abate the advantage, or diſadvantage, which judgment and diſcretion will induce you thereunto, and the help of the Rules following.

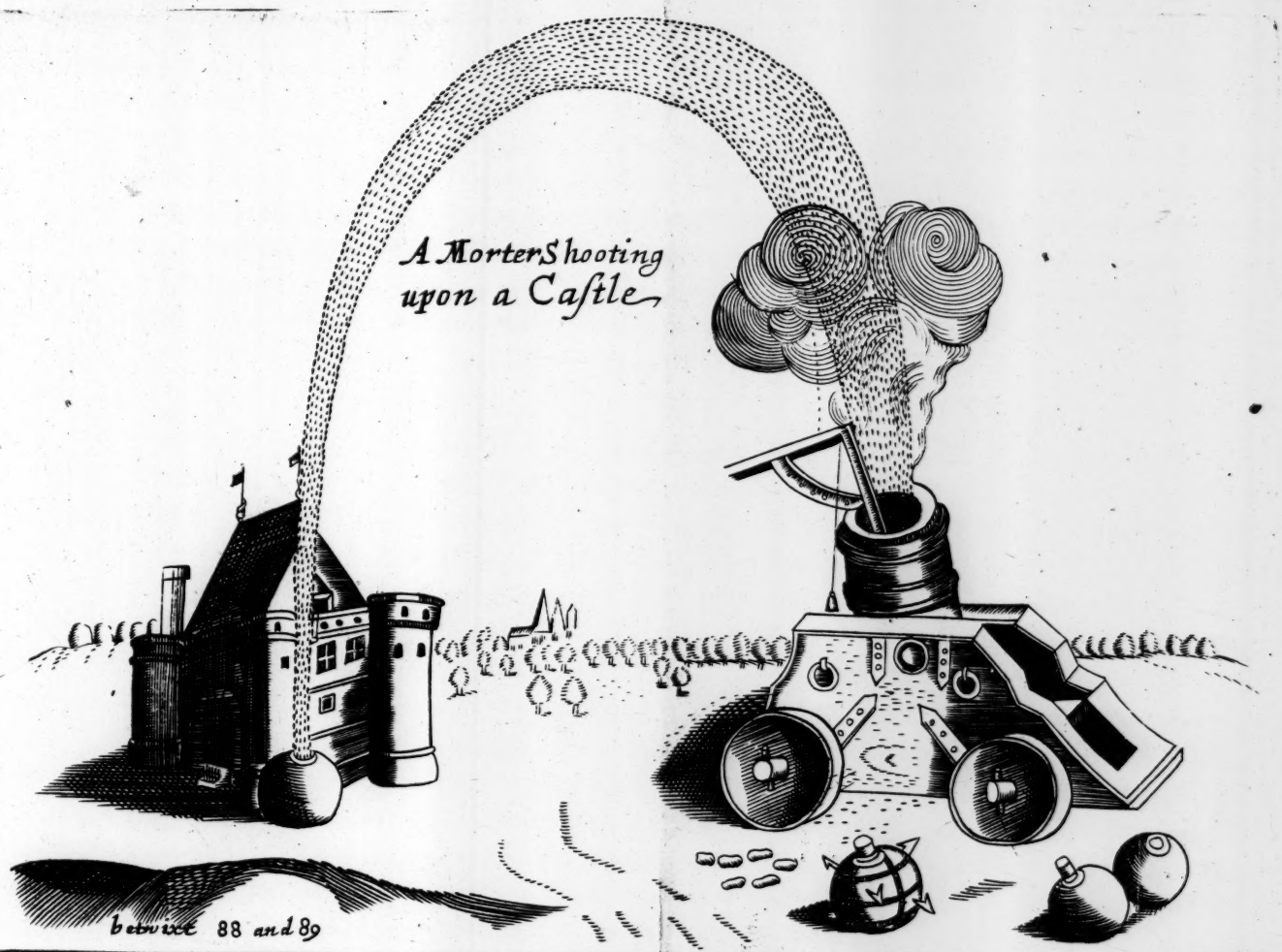
Now we will come to the uſe of a Morter, and that in this example following; Suppoſe an Enemy be approached to the *Baſis*, or foot of a Wall or a Bulwark, and there is a rooting, and begins to make a Mine, and having Chambred his Powder, intends to blow it up, and that there is no other means left you, to repulſe and hinder their egreſs and regreſs into it; but by ſhooting out of your Morters ſome Granadoes, Fire-Balls, Stones, and Rubbiſh among them, or at leaſt by caſting many Hand-Granadoes down upon them. To do this either by force or policy, it behoveth a good Canonier or Fire-worker, to know firſt (as hath been taught) how far his Morter will carry a Granado, or any ſolid thing elſe, which ſhall be ſhot out of it, being ſet upon ſuch and ſuch a degree and elevation as the Morter Figure will ſhew you. As for Example, take your aim level with the mould or mouth of your Morter, noted A upon the Quadrant, and it will carry 200 paces, where you ſee the Granado falls upon the letter A; but your morter being elevated to the mark B, it then will carry its Bullet 487 paces; if to the ſecond C, then 755 paces; if to the third D, it will carry 937 paces; if to the fourth E, then 1065 paces; if to the fifth elevation F, then 1132 paces; if to the ſixth G, which is in the midſt of the Quadrant, and lyes then upon its higheſt elevation, it will carry 1170 paces, as you may ſee by the ſeveral falls of the Bullets upon every Letter. The ſecond Figure ſhews you a Morter caſting a Granado upon a Caſtle, as you may ſee by the Example.

Another Table of Diego Uffanoes for Morter Pieces, with their Randoms made for every degree, between the Level and 90 degrees, as followeth.

Deg.	Pac.	Deg.	Deg.	Pac.	Deg.	Deg.	Pac.	Deg.
0	100	89	16	392	73	31	539	58
1	122	88	17	406	72	33	543	57
2	143	87	18	419	71	34	549	56
3	364	86	19	432	70	34	552	55
4	285	85	20	445	69	35	558	54
5	204	84	21	457	68	36	562	53
6	224	83	22	468	67	37	568	52
7	243	82	23	479	66	38	573	51
8	262	81	24	490	65	39	477	50
9	280	80	25	500	64	40	580	49
10	297	79	26	510	63	41	582	48
11	314	78	27	518	62	42	583	47
12	331	77	28	524	61	43	584	46
13	347	76	29	526	60	44	582	
14	363	75	30	534	59	45	582	
15	377	74						

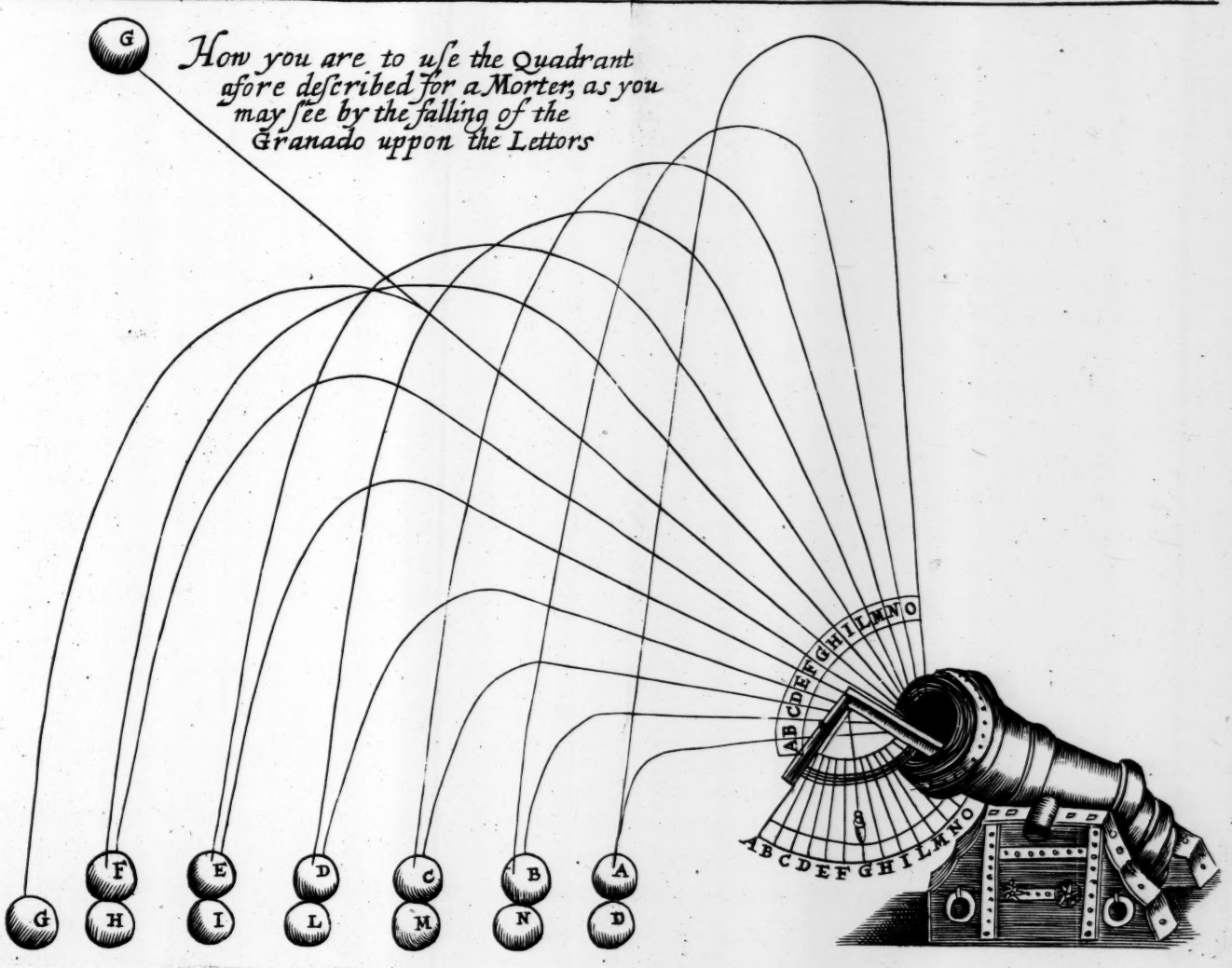
THE

A Morter Shooting upon a Caſtle



betwixt 88 and 89

How you are to uſe the Quadrant afore deſcribed for a Morter, as you may ſee by the falling of the Granado uppon the Lettors



THE Compleat Gunner

THE THIRD PART.

OF *ARTIFICIAL FIREWORKS.*

THe number of artificial Fire-works which are practiſed as well in Armies upon Land in the attacquing and defence of places, as in defence of Ships at Sea, whereby warlike Executions may be performed, are many and various, according to the ingenuity of the Fire-Maſter: And the wayes of preparing them are ſo many, as it is impoſſible for us in this room we have allotted to preſcribe all that are known. We ſhall therefore be contented to make choice of ſome of the beſt and principal things among ſo great a number, but more particularly of ſome moſt admirable inventions; and we ſhall give a Chapter to every kind of Fire-work, conſidering they differ among themſelves both in faſhion and effect, and every one hath its name which is particularly applyed to it. But before we begin with our compoſition we ſhall begin with the particulars, and their preparation unto this work, whereby they may be the more exalted, and have the greater efficacy. The more principal materials, that is, Peter, Charcoal and Sulphur, are mentioned at large in my firſt part of Gunnery, and therefore we ſhall proceed.

CHAP. I.

To prepare Oyl of Sulphur.

TAke a good quantity of clarified Sulphur, (the way of Clarification we have shewed before) melt it over a very gentle fire in an Earthen or Copper Veſſel, then take old red Tyles that have been already uſed in buildings, or if you cannot find ſuch, take new Tyles that are well baked, and that have not taken dirt, break them in pieces as ſmall as a Bean, and throw them into melted Brimſtone, then mingle your Brimſtone with the remaining fragments of the Bricks, until they have drank up all the Sulphur, then let them be put into a Limbeck upon a Furnace to diſtil, and after the Oyl is drawn according to a Chymical order it will be very excellent, and aboveall, have a very combuſtible quality, proper to the Compoſitions of artificial fires.

To prepare Oyl or Balſam of Sulphur.

Fill a long body of Glaſs full of Sulphur well powdered, then pour upon it Oyl of Turpentine, or Oyl of nuts, or Juniper, in ſuch a quantity that the oyl with the Sulphur may fill but the half part, place it in an Iron Kettle, with Sand round about it, and a ſmall heat for 8 or 9 hours, and you will ſee that the Oyl of Turpentine will convert the Brimſtone into a red Oyl, as fiery and combuſtible as before.

There are thoſe that take the following matter to the preparing the oyl of Sulphur, to the end it may be rendered more combuſtible, *viz.* Sulphur 1 *l.* of quick Lyme half a pound, of Sal-armoniac 4 ounces.

Above all this, the Chymiſts know how to prepare a certain oyl of Sulphur, (which they call a Balſam) of which the virtues are ſo admirable, that they admit not any body, either living or dead, to be touched with putrifaction, but will conſerve it in ſo perfect and entire ſtate, that neither the pernicious Influences of the celeſtial bodies, nor that corruption which the Elements produce, nor that which reduces things into their Principles, can any way damnifie it, if anoynted with it. There is alſo from it prepared a certain fire (as *Tritemius* teacheth) with flowers of *Sulphur*, *Borax* and *Brandy-wine*, which will remain many years without extinguiſhing of it ſelf. Others that are knowing, do atteſt that a Lamp may be filled with ſuch like Oyl, from whence all that are within the Light of it, will appear as if they had no heads.

There is another way of making Oyl of Sulphur which is very admirable and excellent, which is prepared thus. Incorporate well together an equal proportion of Sulphur and Salt-Peter, reduce them into moſt ſubtile Powder, and paſs it through a fine ſieve, then put them into an Earthen Pot, that hath never been uſed, and pour upon them Vinegar made of *White-wine* or *Aqua-vitæ*, as much as will cover the Powder; Cloſe the Pot in ſuch manner that no air may any wiſe enter, and put it thus in any hot place ſo long time until all the vinegar be digeſted and vaniſhed. Laſtly, take that matter which reſts in the Pot, and draw from thence an oyl, by Chymical Inſtruments proper to this work.

CHAP.

CHAP. II.

The preparation of the Flowers of Benjamin.

TAke Benjamin a certain quantity of ounces, put it into a Gourd or a Limbeck glaſs, and cloſe it well with a blind head (as they call it) then have in readineſs an earthen veſſel, ſet it upon a Tresfoot, or for the more certainty upon a ſmall Furnace, place it in your glaſs body, and compaſs it well about with fine Sand or aſhes ſo high as the matter is in the glaſs; after make a moderate fire under it, for fear the Limbeck heat too ſoon, and be too hot, for that will make the flowers become citrine or yellow, when they ought to be as white as Snow. Obſerve when you ſee the flowers begin to raiſe a vapour or ſmall fume, continue your fire in that ſame degree the ſpace of one quarter of an hour; after you ſhall ſee the flowers riſen unto the internal Superficies of the blind head, then take it away carefully, and put to it another that ſhall be quite cold, and put that which you have taken off upon a white paper until it be cold, then gently with a Feather or wooden Spatula, cauſe the flowers to come forth of the blind head, and gather them together carefully: thus you may add a third or fourth blind head, and in time many, until all the Benjamin ceaſe to fume.

Benjamin may be made into flowers another way, thus; put into a glazed pot a certain quantity of ounces of Benjamin, and place it upon warm aſhes, and when you ſee it begin to fume, cover the veſſel with a Cornet of paper made in the form of a Cone, and a little larger than the orifice of the pot, leave it there about one quarter of an hour, after take off the Cornet, and take the flowers and gather them together; then put upon the veſſel another Cornet of paper, and let it ſtand as long as before; take it off, and gather the flowers to the former, and continue thus putting Cornet after Cornet, until your flowers be entirely evaporated.

CHAP. III.

The preparation of Camphire.

TAke Juniper Gumm (which is called ſomtimes) Sandarach, white varniſh, or Maſtick moſt ſubtilly powdered 2 *l.* white diſtilled vinegar as much as is neceſſary to cover the Gumm in a glaſs, ſet it deep in horſe-dung the ſpace of 20 days; then take it and pour it forth into another glaſs Veſſel with a wide mouth, and let it ſtand thus in digeſtion a whole moneth, and in it you ſhall have Camphire congealed in form of a Cruſt of bread, and which hath in ſome meaſure the reſemblance of the veritable or true Camphire. The Camphire hath ſuch a love for the fire, that being once lighted, it goeth not out until it be quite conſumed. The flame that comes from thence is very clear, and of a very agreeable odour; after it hath remained ſuſpended in the air ſome time it vaniſheth inſenſibly. The cauſe that produceth all theſe rare effects from Camphire, is by reaſon its parts are extream ſubtil and airy.

I do add to all this, that it may be eaſie to reduce Camphire into Powder, to make it uſeful in artificial fireworks, if a man crumbles it and beats it gently, rouling it with Sulphur. The oyl of Camphire, which ſerves alſo for the ſame effect, is made by adding a little of oyl of ſweet Almonds, and ſtir them well together in a braſs Morter, and peſtle of the ſame metal, until all be converted into oyl of a greeniſh colour.

Or a man may put it into a Glaſs Viol which muſt be cloſe ſtopped, provided alſo that the Camphire be true and natural, and not a Cheat; then put that Glaſs into a warm Furnace, and draw it out, when you ſhall ſee all the Camphire turned into a pure clear oyl, which will burn with an admirable vivacity.

CHAP. IV.

Water of Sal-armoniac.

TAke Sal-armoniac 3 ounces, Salt-Peter 1 ounce, reduce them into a moſt ſubtil Powder, and mix them well together, after put them into a Limbeck, and then pouring on them ſome of the beſt and ſtrongeſt Vinegar, you may diſtil the ſame into a water with a ſmall fire.

CHAP. V.

Of a certain artificial Water which will burn upon the Palm of your hand without doing any harm.

TAke *Oleum Petrolj*, and of *Terebinthi*, and of *Calx viva*, of Mutton fat, and of Hogs Lard, of each equal parts, beat them well together, until they be well incorporated, then cauſe them to be diſtilled in warm aſhes, or upon burning coals, and you ſhall draw from thence an excellent oyl.

CHAP. VI.

To prepare Fire-Spunges.

TAke of the oldeſt and greateſt Toad-ſtools which grows at the Root of Aſh, Oak, Birch, and Fir-tree, with many other Trees which produce them freely; get a good parcel, ſtring them, and hang them in the Chimney, and leave them to macerate; being well mortified and macerated, take and cut them in pieces, and then beat them with a wooden Mallet; this done, boyl them over a ſmall fire in a ſtrong Lye, and a ſufficient quantity of Salt-Peter, until all the humidity be evaporated: At laſt, having put them upon a Plank or even board, put them in a warm Oven, and let them well dry there; having drawn them from thence, you muſt beat them with a wooden Mallet as before, until it become wholly ſubtile and ſoft; being thus prepared, you muſt keep them in a commodious place to ſerve you upon occaſion.

CHAP.

CHAP. VII.

How to prepare Match or Tow for Artificial Fires.

MAke Cords of Tow, Hemp, or Cotton, which you pleaſe, of two or three twiſts, not made too hard, put them in a new Earthen pot Verniſhed, pour upon them Vinegar made of good white Wine four parts, of Urine two parts, of *Aqua vitæ* one part, of Salt Peter purified one part, of Cannon Powder reduced to Meal one part: Make all theſe Ingredients boyl together upon a great Fire, to the Conſumption of all the Liquor; then ſpread upon a great ſmooth Plank or Board, the Meal or Flower of the moſt excellenteſt Powder that you can get. Having drawn your Match out of the Pot, roul them in the Powder, and then dry them in the ſhade or Sun, for it matters not which, and the Cords or Match that are thus prepared will burn very quick.

Francis Jouchim Prechtelin, in his ſecond part of his Fire-works *Chap.* 2. deſcribes a certain Match, which is extream ſlow in burning, and is thus made; take Maſtich two parts, Colophonia one part, Wax one part, Salt-Peter two parts, Charcoal half a part, then, having melted all and mixed them well upon the fire, take a Match made of Hemp or Flax of a ſufficient bigneſs, and draw it through this Compoſition, making it go down to the bottom of the Veſſel, drawing it often through, until it hath gotten the bigneſs of a Candle, and when you deſire to uſe it, light it firſt, and when it is well lighted blow it out, and there remains none but a burning Coal.

CHAP. VIII.

Of certain Antidotes excellent and approved againſt the burning of Gun-powder, Sulphur, hot Iron, melted Lead, and other like accidents, drawn from the particular Experiments of Cozimu Nowicz.

SECTION. I.

BOyle Hogs greaſe in common water, over a moſt gentle fire, the ſpace of ſome time; then take it from the Fire, and let it cool, and after expoſe it to the fair and clear weather three or four nights; after having put it into an Earthen pot, melt it again upon a ſmall fire, and being melted, ſtrain it through a Cloath into cold water, after waſh it many times with good clean and freſh water, until it come as white as ſnow; this done, put it into a glazed pot to ſerve you at your occaſions. The uſe is thus, you muſt annoint the burnt part as ſoon as you can, and you will ſee a quick and admirable effect.

SECT. II.

Take Plaintain water, Oyl of Nuts of *Italy*, of each as much as you please.

SECT. III.

Take Mallows water, Rose water, Plume Allum, of each as much as is necessary, and mix them well together with the white of an Egg.

SECT. IV.

Take a *Lixivium*, made of *Calx Vive* and common water, add to it a little Oyl of Hempseed, Oyl Olive, and some whites of Eggs, mingle all well together, and annoint the burnt place with this Compostion. All these Oyntments cure burnings without causing any pain. These I have often experimented upon my self.

Some Receipts from divers Authors.

Take Oyl of Olives, Oyl of sweet Almonds, Liquid Vernish, each one part, juice of Onions, two parts, with these chafe the part affected.

If there be already blisters raised and Ulcerations in the parts, this following Oyntment is most excellent.

Boyle a great quantity of the second Rind of Elder tree, in Oyl of Olive, then pour it through a Linnen cloath, add to it a little after two parts of Cerus or burnt Lead, of Lytharge of Gold, of each one part, put them into a Leaden Morter, and then stir them about and mix them so, that they become in the form of a Linament.

Take melted Lard, pour it into two Ounces of Morrel water, and one Ounce of Oyle of Saturn, then mingle them well together: this Remedy is soveraign.

Take the Mucilage of the Roots of Henbane, and of the Flowers of Poppies, of each one Ounce, Salt Peter one Ounce, mingle them all with Oyl of Camphire, and make a Linament according to Art.

Or take the juyce of Oynions rosted in embers two Ounces, Nut Oyle one Ounce, mingle them all well together.

Or take of the Leaves of Ivy two m. or handfuls well beaten up with Plantain water, Oyl Olive one pound, make all boyl with four Ounces of good white Wine, until the Consumption of the whole Wine, at the end of the decoction add Wax as much as is necessary, to give him the form and consistency of a Linament.

Again, take old Lard, let it be melted over the flame, and poured into two Ounces of the juyce of Beets and Rue, of the Cream of Milk one Ounce, Mucilage of Quince-seeds and Gum Tracanth, of each an Ounce and a half, mix them well together, and make thereof a Linament. [This remedy is none of the worst, we took it from *Joseph Quercetanus, in libro Sclopetrio.*

CHAP.

CHAP. IX.

Of Hand Granadoes.

THe Hand Granadoes reſpecting their form, are Globically or perfectly round and hollow in their interior part in manner of a Sphere; they are called Hand Granadoes, or Handy Granadoes, becauſe they may be graſped in the hand, and thrown to the Enemies; and if we ſhould dwell upon the denominations of the Latine, we may call them as they do, *Granades Palmares*, they are commonly of the bigneſs of a Bullet of Iron of 5, 6, and 8 *l.* they weigh ſometimes 1 *l.* and ſometimes one pound and a half, ſome are of two pounds, and others of three pounds; there is given to theſe ſort of Globes the names of *Granadoes*, by reaſon of the great reſemblance they have with the Fruit *Punique*, which we call *Pom-granad*; for as theſe do ſhut up in their rinds a great quantity of grains; ſo our Military Globes are filled with a number of Grains of Powder, almoſt innumerable, the which having received the Fire, do break into a thouſand and a thouſand ſhivers, leaping againſt the Enemy, and piercing if it could all ſuch things as it meets oppoſing its violence. They are generally made of Iron or Copper, carrying in its Diameter about three Ounces, being about the length of a Barly Corn in thickneſs of Metal; they are filled commonly with Gun-Powder, and ſometimes of other Compoſitions, there is added to its Orifice a ſmall Pipe commonly called a Fuſe, which is filled with a matter or Compoſition that is ſlack or ſlow in burning, but nevertheleſs very ſuſceptible of the Fire, and capable to hold fire ſome time, for fear that it ſhould break in the hands of thoſe that mannage it, and intend to throw it.

There is amongſt Fire-Maſters accounted three ſorts of Hand Granadoes, the firſt and moſt common are made of Iron; others are made of Braſs, allayed with other Metals in the melting; the third ſort is of Glaſs.

If you cauſe them to be made of Iron, take ſuch as is moſt fragile, and as little wrought as poſſible you can get; if you will caſt them of Copper, you muſt allay ſix pound of Copper, with two pounds of Tyn, and half a pound of Marcaſite, or you may put one part of Tyn with three parts of Lattin or of *Auricalque*. Thoſe that are made of Iron are in thickneſs about the ninth part of the Diameter; thoſe that are made of Braſs muſt have one tenth part of the Diameter in thickneſs of Metal. Laſtly, ſuch which you cauſe to be made of Glaſs, muſt have one ſeventh part of their Diameter in their thickneſs.

The largeneſs of the Orifice in which you muſt put in your Fuſe made of Wood, whoſe upper part muſt be about $\frac{1}{3}$ the Diameter of the Granado, and the ſmall hole in the Fuſe ſhould have the largeneſs of $\frac{1}{12}$ of the ſame Diameter, the reſt of the capacity of the Shell muſt be filled with well grain'd Powder, the length of the Fuſe muſt be about $\frac{2}{3}$ of the Diameter, and the top muſt be broad, and a little rounding like a Hemiſphere, the hollow and inner part of the Fuſe muſt be about $\frac{1}{2}$ Diameter at the ſmall or inner end, and $\frac{1}{3}$ at the outer end: Men do generally fill the void place with Powder ground moſt ſubtilly, which muſt be moiſtned with Gum-water, or diſſolved glue, that it may joyn the better. As for the Fuſes, they muſt be filled or charged with one of the Compoſitions hereunder written; afterward you muſt faſten it well and cloſe with Tow or Okham, and the Pyrotechnian Lute which the *Germans* call *Kit*, which is made of four parts of Ship Pitch, two parts of Colophonia, one part of Terrebinthe, and one part of Wax; you muſt put all theſe Ingredients in a glazed Veſſel, and melt them upon a ſmall fire, then mix and mingle them well together.

Compoſitions for Charging the Fuſes of the Hand Granadoes.

Powder	1 l.	*Salt-Peter*	1 l.	*Sulphur*	1 l.
Powder	3 l.	*Salt-Peter*	2 l.	*Sulphur*	1 l.
Powder	4 l.	*Salt-Peter*	3 l.	*Sulphur*	2 l.
Powder	4 l.	*Salt-Peter*	3 l.	*Sulphur*	1 l.

Another ſort of Granadoes.

I ſhall here repreſent you with a Hand Granado, which may be hid at the entring of a paſſage, or any ſuch place where we ſuppoſe the Enemy muſt come: This Granado hath two holes oppoſite, paſſing juſt croſs the Diameter, in which muſt be faſtned a Fuſe of Wood or Metal with holes in ſeveral places, and all about it within let there be beaten Powder, and through it you muſt paſs a common match, lighted at one end, and at top let there be a third hole, by which it muſt be charged with a good grain'd Powder, which muſt be cloſe ſtopt again with a Tampion, and then is your Granado prepared. I ſuppoſe it not neceſſary to ſay much of the uſe of this Granado, and ſince it is ſo eaſie to be underſtood by what we have ſaid, and that the occaſion you will have of ſuch things will forge your Inventions enough to put them in practice.

CHAP. X.

How and where a man ought to heave Hand-Granadoes.

According to the definition which we have given of them, it is moſt evident, and I ſuppoſe no body will doubt, that they are to be taken in the hand, and that we muſt graſp them to throw them at the Enemy. It is ſaid before that this kind of Arms is as well defenſive as offenſive; therefore we ſhall not reſt upon the proof of theſe things; thoſe that have been at the managing of them muſt inſtruct them that are ignorant.

We ſhall ſay only this, that the Places where theſe Hand Granadoes are uſed at Sea, are where Ships are Board and Board to clear the Enemies Decks, ſo that the way may be cleared there. Upon Land Service they are uſed immediately after the good and happy ſucceſs of a Mine which hath made a great overture in a Rampire, overthrowing one part of the Wall, Bulwark, or Baſtion, to give place to the Aſſailants, to do their endeavour to get into the breach; it is there that the Beſieged as well as Beſiegers may make uſe of theſe Hand Granadoes; 'tis there where you ſhall ſee the more generous of both ſides armed with Fire and Flames, defending valiantly the quarrel of their Prince, the intereſt of their Party, their Liberties and their Lives. They are imployed alſo upon other occaſions, to wit, when the Beſiegers are come up to the Walls of the Rampire, and ſo well placed, that making winding Stairs in the thickneſs of the Platform, they mount inſenſibly by retact; ſo that the Beſieged cannot any way hinder by the defence of their Flanks, nor be kept ſafe by the Rampires themſelves. Upon theſe occaſions I ſay, the Beſieged ought to pour down a quantity

a quantity of Hand Granadoes from aloft, or from the top of the Walls, upon their under-miners.

And ſometimes they are alſo thrown at a diſtance greater than ordinary, according to the occaſion; but when this cannot be done by the natural ſtrength of a Soldier, without the aid of ſome artificial Inſtrument, the Maſters in this Art have invented certain ſmall Engines, made like unto one of our Ducking-Stools, with a Rope at one end to pluck it down by force, and at the other end a hollow place to lay the Balls in that are to be thrown, and with this Engine well contrived, one may throw upon the Enemy, not only Hand Granadoes; but alſo a quantity of other Artificial Military Fires, as gliſtring or ſhining Globes, Bombards, Fire-pots, and many other ſuch like things, of which we ſhall ſpeak in their place, may be thrown at a greater diſtance than is poſſible by the hand only.

This Inſtrument is not very difficult to make, it may eaſily be comprehended by what we have ſaid. I ſhall only advertiſe you of one thing, that the longer the arm of the Engine is on that ſide that is to hold the Granadoes, more than the other part to which the Rope is faſtned, the greater force the Engine will have; but you muſt underſtand this meaſure to be made from Axes or Iron Rolls, upon which the Arm moves.

CHAP. XI.

Of gliſtring or bright ſhining Fire-balls.

DIſſolve upon the fire in a Braſs or Earthen Veſſel an equal portion of Sulphur, black Pitch, Rozin, and Turpentine; then take a Ball of Stone or Iron, that the Diameter be far leſs than the Diameter of a Cannon, or Morter Piece, for which you intend this Globe; plunge this Shot in this melted matter until it be all over cover'd with the matter about its *exterior* part, draw it from thence, and role it gently in Corn Powder, that done, cover it all over with a Cotton Cloath; then plunge it again in your Compoſition, and reiterate the rolling it in Powder, as before, then cover it a ſecond time with another Cotton Cloath; and thus continue dipping your Bullet, and wrapping it about with Cloath, until your Shot has acquired a juſt bigneſs, exactly to fill the Orifice of the Engine, remembring that the laſt Coat of the Shot muſt be of Corn'd Powder: Being then thus prepared, it muſt be put into the Cannon or Morter Piece naked, without any other thing compaſſing it, immediately upon the Powder in the Chamber, which muſt make the Bullet come forth; Then give fire freely to your Piece, to throw the ſhot where you intend it.

CHAP. XII.

Of Balls which Cast forth so great a smoak, that they blind whomsoever they come near.

IT is accustomed to do great execution by favour of the night, in occurrences of War, as well as in many other occasions; I mean not here to speak of the darkness of the night, for that is naturally effected by the first Causer of all things, from the order that he hath established amongst the Beings, but I intend only here to treat of the darkness that is made Artificially, and particularly such as may be produced and made to last a little time in a close or narrow place, according to the Rules of our Art, to be made for the blinding of the Enemy, which would force into our beings, and would attaque us by main strength, in a design to take away our Lives, Honour, and Goods; or when we have a design to facilitate the passage for the Assailants, in confounding or oppressing the Besieged in their Forts, with a cloudy and thick fume, in such a sort that one may take them as amazed Fish in troubled waters. For this purpose are Globes prepared, which whil'st they are on fire, produce a smoak so vehement and unpleasant, and in so great aboundance, that 'tis impossible to withstand the incommodity without bursting asunder; see here the Method. Take Ship Pitch in the Stone 4 *l.* Liquid Pitch 2 *l.* Colophonia 6 *l.* Sulphur 8 *l.* Salt-Peter 36 *l.* melt all these Drugs upon burning Coals in any vessel whatsoever, adding after 10 *l.* of Coal of Sawdust made of the Pine or Firr-Tree 6 *l.* Crude Antimony 2 *l.* incorporate and mix them very well together; then put into this melted matter Tow, Hemp, and Linnen Cloaths a great quantity, and boyl them well in this Composition, and when they have drank up all the matter, then form them into Balls of such a bigness as you please, so that it may be cast with the hand, or with the Engine mentioned in the last Chapter, according as you shall find most convenient. And this is our true way to make Night at Noon-day, to obscure the Sun it self, and so blind the Eyes of the Enemies for some time. And this is the most lawful way that one may follow, because it shews its original from natural things, and we may believe that it is always sufficient justice, so that the Wars where such things are practised, be not unjustly enterprized.

CHAP. XIII.

Stink Balls.

STinking Globes are made to annoy the Enemy by their stinking vapours and fumes disagreeable to Nature; nay so unsufferable to the Nose, and to the Brain it self, by its most violent stink, that by no means it can be endured. The preparation is as followeth, Take of Powder 10 *l.* of Ship Pitch 6 *l.* of Tar 20 *l.* Salt-Peter 8 *l.* Sulphur Colophonia 4 *l.* make all these Ingredients melt at the fire by a small heat, in an Earthen or Copper vessel, and all being well melted, throw into the melted matters 2 *l.* of Coal dust, of the cuttings or filings of Horses Hoofs 6 *l.* *Assa fœtida* 3 *l.* *Sagapenum* 1 *l.* *Spatula fœtida* half a pound: Mingle and incorporate them well together; then

then put into this matter Linnen or Woolen Cloath, or Hemp or Tow, ſo much as will drink up all the matter, and of theſe you may make Globes or Balls of what bigneſs pleaſeth your ſelf beſt, according to the method and order as we have heretofore preſcribed.

The Globes or Balls may be made Venomous or Poyſonous, if to their Compoſition be added theſe things following, *viz.* Mercury ſublimate, Arſenick, Orpiment, Cinaber, to which may alſo be added many other Poyſonous matters, which I ſhall forbear to mention, conſidering every one by Nature is apt enough to learn to do that which is miſchievous.

CHAP. XIV.

Of the Shooting of Shot made red hot in the Fire.

IT is a practice that hath been practiſed in former times to ſhoot red hot Fire-balls, and was counted of great defence, as you may find amongſt many other things in the Works of *Diodorus Siculus*, where he ſayes, *Tyrios immiſſe in Alexandri Magni machinamenta maſſas magnas ferreas candentes:* Out of many Authors may be proved the cuſtomary uſe in former times of Shooting red hot Pieces of Iron, which we ſhall not dwell upon, but come to the Practice. Firſt, you muſt Charge the Piece of Ordnance according to the cuſtomary manner, his due proportion of Powder, upon this Powder you muſt put a Wooden Cylender or Fidd, of a juſt and equal wideneſs with the bore of the Piece, which muſt be driven very ſtiff home to the Powder, and for your better ſecurity, you muſt put upon this another wad made of Straw, Hay, or of Oakam, or Tow; this being done, let the Piece be laid a little under Metal, and then cleanſe the vacant place or hollow of the Piece with a Spunge, ſo that all the Grains of Powder that are there, may be taken away. This being done, lay your Piece to bear with the place you intend to ſhoot at, according to the method we have given in the ſecond Part of Gunnery, and let your Piece thus remain until you have put in your red hot Bullet: your Bullet muſt be ſure to be exactly round, and not ſo high, but that it may run freely down in the Piece to the wad, the Shot being red hot, take it out of the fire with a pair of Tongs made for that purpoſe, and put it into the Piece, and give an attentive Ear, for as ſoon as the Shot is ſuppoſed to be up to the Wad, give immediately Fire to your Piece of Ordnance.

There are others which put into their Pieces Boxes made of Plate, of Iron or Copper. Others do put into their Pieces Potters Clay, and upon them the fiery Bullet, which with a quick hand they thruſt home with a Rammer, which ought to be defended from fire by lining the Rammer head with Copper. But theſe are more perillous; and therefore we account that method above to be the beſt, and moſt free from danger.

CHAP. XV.

To Arm Pikes to defend a Ship or any other place.

TO arm Pikes, to defend a ſhip, or breach, or to enter the ſame, or to ſtick in the ſides of a ſhip, or other place, take ſtrong Canvas, and cut it in length about a foot, or 14 inches, and ſix inches high in the Center, and let the ends be both cut taper-wiſe, then faſten the Canvas at both ends with ſtrong twine, and fill it with this receipt.

Powder bruiſed 8 parts, Peter in Roch 1 part, Peter in meal 1 part, Sulphur in meal two parts, Rozen Roch three parts, Turpentine 1 part, Verdigreaſe ½ part, Bole-armonick ½ part, Bay ſalt ½ part, *Colophonia* ½ part, Arſnick ½ part, mix them very well together, and try them in the top of a Braſs Candleſtick, when the fire doth burn furiouſly with a blew and greeniſh colour, then fill the Canvas, and roul it over, being firſt armed with ſtrong twine all over, with this liquid mixture molten in a pan, Pitch four parts, Linſeed Oyl 1 part, Turpentine ½ part, Sulphur 1 part, Tarr ½ part, Tallow one part; and as ſoon as this is cold, bore two holes in each of the ſame next the Iron an inch deep, with a ſharp Iron Bodkin, filling the ſame with fine bruiſed powder, and putting in every hole a little ſtick of two inches long, which are to be taken out when you would fire the ſame; this compoſition will burn furiouſly.

And remember you cut off the ſtaff ſome three inches from the work, and put thereon a braſs ſocket of five or ſix inches long, and then cut the end of your ſtaff to fill the ſocket, for when you fire your work, you may ſtick it in the ſide of a ſhip, and pull the ſtaff out again, ſo will not the work be ſo eaſily avoided, as when the ſtaff was on, and hangs at length, becauſe the very weight of the ſtaff, and length thereof, will be a means to weigh down the work, or that the enemie may come, and thereby pull it out, or beat it off quickly; let the Compoſition and work contain in weight about 7 pounds, then will it do execution, and work a better effect, than if it were of leſs weight, by much, by reaſon the compoſition elſe would be waſted, before it comes to effect its Execution.

To burn the ſayls of Ships a pretty diſtance, or to fire Thatch'd houſes, Corn-ſtacks, or any other combuſtible matter apt to burn, when you cannot come to the ſame; it is good to have certain ſtrong Croſs-bows to bend with Racks or Gaffels, and ſo ſhoot Arrows armed at the heads with Wild-fire, made of the compoſition as above, and about three inches in length, and one inch and a half in the Diameter, tapred as afore in all points: or you may have long bows, but then let your Arrows be alſo longer, which for divers ſervices may do great good.

CHAP. XVI.

To charge Trunks with Balls of Wild-fire.

TO charge Trunks to ſhoot little Balls of wild-fire, either to offend or defend, you muſt firſt charge him with two inches of good Powder, and then with a Ball of wild-fire a little lower than the concave of the Trunk, let the Ball be bored through croſs-ways, and primed full of fine powder. Laſtly, with ſlow receipt, then with powder, then with a Ball again as aforeſaid, until you have filled the ſame within ¼ of an inch of the mouth, which would be filled up with fine powder and receipt mixed together. Some do uſe to have at the mouth two Iron ſtirts to ſtick them in the ſide of any thing,

or

or to defend ones ſelf from the Enemy from taking it off with a thruſt while they do Execution.

To make the Ball.

The Ball of Wild-fire muſt be thus made, Take untwiſted Match, Tow, and Hemp, the which would be moiſtned in *Aqua-vitæ*, or boyled in Salt-Peter water: then take of bruiſed Powder ſix parts, of Salt-Peter one part, of Brimſtone finely beaten one part, of coal made of light wood moiſtned with a little Linſeed-oyl and Turpentine wrought together, one part: then lay the Tow or Oakam, abroad in thickneſs of the back of a knife, and as broad as a great Oyſter-ſhel, put into the ſame as much as you can graſp together in your fiſt, and tying the ſame hard with a pack-thread, coat it over with molten Brimſtone, and when you would uſe the ſame, bore it through with a Bodkin, and fill the holes full of fine powder bruiſed.

To make Bullets of Wild-fire to ſhoot out of a Trunk, which will be as hard as a Stone.

Take Sulphur in meal ſix parts, of Rozen in meal ſix parts, melting the ſame in ſome Pot over a ſlow fire: then take ſtone pitch one part, of hard wax one part, of Tarr ¼ part, of *Aquavitæ* ⅓ part, of Linſeed Oyl ½ part, of Verdigreaſe ¼ part, of Camphire ½ part, melting all theſe together. Likewiſe ſtir into the ſame of Peter in meal two parts, and taking it from the fire, put therein four parts of bruiſed powder, working the ſame well together in your hands, and roul it round of the bigneſs you mean to make your balls of, boring two holes through the ſame croſs-ways, which muſt be primed with bruiſed powder. Theſe balls being cold, will grow very hard, and fired will burn furiouſly.

To make Hedg-hogs.

To make Hedg-hogs, or balls, you muſt fill them with the ſame receipts you do your Arrows, and Pikes, and let them be five inches in the Diameter, and well armed with twine before you coat them, and after boared two holes, and primed with fine powder: then put in two ſticks, and uſing them, pull them out again, and at the ſaid holes fire them. The ſpikes end of Iron muſt be like Deaths Arrow heads, five or ſix ſtirts a piece to hang in the ſayls, or ſtick in or upon any place aſſigned; and remember in the arming, to leave a nooſe to throw him being fired, out of your hand.

To make Powder-pots.

They are made of black Potters clay, or thick glaſs, round Bottles with ears to tye matches, lighted at both ends, the pots or glaſſes are to be filled with dry fine powder, and thrown upon the decks, or other where, which will much prejudice the Enemy, and many times fire their own Powder-cheſts.

ARTIFICIAL FIRE-WORKS FOR RECREATION.

AMongſt all Artificial fires that have been put in practice many years, the *Fuzees* (which the Latins call *Rochetæ*, and the Greeks *Pyroboli*) have alwayes had the firſt Rank; (nevertheleſs this Greek word doth not well agree with the Etymologie of the word *Rochetæ*) ſeeing that πυροβολον ſignifies properly *Tela ignita*, that is, burning darts or Arrows, the Italians call them *Rochete* and *Raggi*, the Germans *Steigen de Kaſten*, *Ragetten*, and *Drachetten*, the Poles *Race*, the French *Fuzees*, the Engliſh *Rockets*, or *Serpents*. If we conſider the invention of them, it hath been of ſo ancient ſtanding, that the conſtruction is now very common and familiar amongſt all the *Pyroboliſts* and Fire-maſters; the which, although it appears very eaſie in it ſelf, yet there is in it labour, and requires that he that applyes himſelf to this work ſhould not be careleſs, but on the contrary take all the care and diligence that poſſibly he can have for the preparing of ſuch perilous things, conſidering likewiſe the expences and loſſes are irreparable after the experiment made; and ſeeing that nothing can be put in practice in publick Recreations without theſe *Fuzees*, therefore I think I am ſomething obliged here to ſhew the true way of preparing them, with their particular uſe.

CHAP. I.

How to make Rockets.

I Intend not here to write the Conſtruction of Moulds fit for this purpoſe, but rather leave the more curious Students herein to the works of *Caſimier Siemienowicz*, Lieutenant General of the Artillery in the Kingdome of *Polonia*, in his great Art of Artillery written in the French Tongue and Printed at *Amſterdam*, and alſo in our Countrey-men Mr. *Bate* and Mr. *Babington* &c. That which I intend to do, is to teach you how they may be made by hand, or by help only of a Rouler to Roul the Paper upon; let it be turned to the thickneſs you intend, only let the Rouler be 8 times the Diameter in length. If it be three quarters of an inch in thickneſs, the length will be three inches. Roul your Paper hard on the Rouler until the thickneſs be one inch and a quarter Rouler and all; then glue the uppermoſt paper, and the Caſe is made. On the choaking or contracting the paper together at one end, within one Diameter of the end, except only a little hole, about one quarter the Diameter of the bore thereof, to contract theſe Caſes on this manner, do thus, wet the end about one inch in water, then put the Rouler in again, and tye a great packthread about the wet within three quarters of an inch of the end, put another thing almoſt of the ſame Diameter with the Rouler in at the wet end about half an inch, hold it there, get ſome

other

other body to draw the packthread together, you holding the Rouler and Rammer, one put down to the end within one inch, and the Rammer which muſt be little leſs than the Diameter to meet with that end within half an inch, in which the contract or choaking muſt be; the packthread having drawn it together, tye it faſt on that place, take out the Former, let it dry, and it is done; when the hole is contracted together, make it ſo wide as is before raught, with a round bodkin, which you muſt provide for that purpoſe.

CHAP. II.

How to make Compoſitions for Rockets of any ſize.

THeſe ways which I will teach you I take them not upon truſt out of every Author, but ſuch as are men of known experience, as that *Caſimier* before ſpoken of, and others of the like repute. And firſt, for Rockets of 1 ounce, you muſt uſe only Cannon-powder duſt being beaten in a Morter, and finely ſifted, and this will riſe ſwift, and will make a great noiſe, but carries no tayl: Thoſe of moſt beauty in their operation are made of 1 ounce of Charcoal-duſt, eight ounces of Powder, this Compoſition will hold for Rockets of one, two, or three ounces; but for thoſe of four, take three ounces of Charcoal-duſt, to one pound of Cannon-powder duſt, continuing that Rule until you come to Rockets of ten ounces, and from thence to Rockets of a pound; for there uſed to be one pound of Powder-duſt to 4 ounces of Charcoal-duſt. But for better ſatisfaction obſerve theſe Rules.

For Rockets of one pound.

Take Powder 18 *l.* Salt-Peter 8 *l.* Charcoal 4 *l.* Sulphur 2 *l.*

For Rockets of two or three pound.

Take of Salt-Peter 60 *l.* Coal 15 *l.* Sulphur 2 *l.*

For Rockets of four or five pound.

Take of Salt-Peter 64 *l.* Coal 16 *l.* Sulphur 8 *l.*

For Rockets of ſix ſeven or eight pound.

Salt-Peter 35 *l.* Coal 10 *l.* Sulphur 5 *l.*

For Rockets of nine or ten pound.

Salt-Peter 62 *l.* Coal 20 *l.* Sulphur 9 *l.*

For Rockets from eleven to fifteen pound.

Salt-Peter 32 *l.* Sulphur 8 *l.* Coal 16 *l.*

For Rockets from ſixteen to twenty pound.

Salt-Peter 42 l. Coal 26 *l.* Sulphur 12 *l.*

For Rockets from thirty to fifty pound.

Salt-Peter 30 *l.* Coal 18 *l.* Sulphur 7 *l.*

For Rockets from ſixty to a hundred pound.

Take Peter 30 *l.* Sulphur 10 l. Coal 10 *l.*

CHAP. III.

To fill the Rockets with this Composition.

PLace the mouth downwards where it was choaked, and with a knife put in so much as you can of the receits provided for that size at one time; then put down your Rammer, which must be longer and narrower than the Former or Rouler upon which you made the Cases, and with a hammer of a pound weight, give three or four indifferent knocks, then put in more composition with your knife, until it be full, at every time knocking the like as before with the Rammer, until the composition come within one diameter of the bore of the top, there put down a peece of pastboard, and knock it in hard, prick three or four little holes therein, then put fine pistol powder in almost to the top, and upon that another cap of paper, upon which put a peece of leather, that it may be tyed on the top of the Rocket, and fast glued on, then get a streight twig, and bind it upon the Rocket with strong packthred, it must be no heavier, than being put upon your finger, two or three fingers breadths from the mouth of the same, it may just ballast the Rocket; then it is prepared for use.

CHAP. IV.

How to give fire to one or more Rockets.

SEt your Rockets mouth upon the edge of any peece of timber, battlement of a wall, top of the Gunners carriage wheel, or any dry place whatsoever, where the rod or twig may hang perpendicular from it, then lay a train of powder that may come under the mouth thereof, give fire thereunto, and you have done. But if you would fire more Rockets than one, that as one descendeth, the other may ascend by degrees, make this composition following of *Roch peter* 8 ounces, *Quick Brimstone* 4 ounces, and fine Powder dust 2 ounces, which lay in a line from one Rocket to another, they being placed ten inches or a foot one from another, give fire to this composition, and it will work your desire; by causing one to mount into the air when the other is spent; but before you place your Rockets, remember to prick them with the bodkin.

CHAP.

CHAP. V.

Divers and ſundry Compoſitions for Stars.

A Compoſition for Stars of a blew colour mixed with red.

TAke of *Powder mealed* 8 ounces, *Salt-Peter* 4 ounces, *Quick Brimſtone* 12 ounces, Meal all theſe very fine, and mix them together with two ounces of *Aqua-vitæ*, and half an ounce of Oyl of *Spike*, which let be very dry before you uſe it.

Another Compoſition which maketh a white and beautiful fire.

Take *Powder* 8 ounces, *Salt-Peter* 24 ounces, *Quick Brimſtone* 12 ounces, *Camphire* 1 ounce, Meal theſe Ingredients and incorporate them: Now to meal your *Camphire*, take a braſs peſtle and morter, wet the end of the peſtle in a little of the Oyl of Almonds, and it will meal to powder, then keep it cloſe from the air, elſe it will become of no uſe,

Another white fire which laſteth long.

Take *Powder* 4 ounces, *Salt-Peter* 16 ounces, *Brimſtone* 8 ounces, *Camphire* 1 ounce, *Oyl of Peter* 2 ounces, Meal thoſe that are to be mealed, and mix them according to the former directions.

CHAP. VI.

The manner of making Stars; and to uſe them.

TAke little four ſquare peeces of brown paper, which fill with the compoſition you approve of beſt, of the three laſt taught: ſo double it down, rouling it until you make it round, about the bigneſs of a nut, or bigger, according to the ſize of your Rocket, that you intend them for, prime them, withdrawing thorow them Cotton-week, and they are prepared.

You may alſo make them after this manner, you muſt have a rouler which muſt be as big as an ordinary arrow, which ſhall be to roul a length of paper about it, and with a little glue paſt it round; when it is dry draw out the rouler, and fill it by little and little, with a thimble; ſtill thruſting it down, every filling of a thimble, with the rouler; which being filled, cut it in ſhort pieces, about half an inch long; then having in readineſs either hot glue, or ſize, mingled with red lead, dip therein one end of your ſhort peeces, leſt they take fire at both ends together, and becauſe that it may not ſo eaſily blow out: theſe being thus finiſhed, ſet them to dry until you have occaſion to uſe them: and then putting the open end in powder on the top of the Rocket, in that place after the firſt paſtboard, or cover, is placed in a Rocket; next the compoſition, where I taught you before to put powder for to make a report:

which now you must leave out to place in these Stars; after this manner make two or three holes in that pastboard, which prime with powder-dust: and thereupon put a little Pistol powder, to blow the Stars out when the Rocket is spent: after the powder, put as I have said before, the open ends of these Stars, down upon that powder: when you have put them so close as they can stick one by the other, put a little small corned powder on the top of them, to run between them, and put another tyre of Stars upon that, and in like manner a third tyre upon them, till you come to the top of the Rocket-case, there put a paper over the head of it, and tye it close about the top, that none of the powder come from under or between the Stars.

How to prepare the Cotton-week, to prime the first sort of Stars.

Take Cotton-week, such as the Chandlers use for Candles, double it six or seven times double; and wet it thoroughly in *Salt-peter* water, or *Aqua-vitæ*, wherein some *Camphire* hath been dissolved, or for want of either in fair water, cut it in divers pieces, roul it in mealed powder, dry it in the Sun, and it is done.

CHAP. VII.

How to make silver and golden Rain, and how to use them.

NOw I shew you the order of making golden Rain, which is after this manner; you must provide store of Goose-quills, which being provided, you must cut them off so long as they are hollow, the composition to fill these must be made thus; two ounces of cole-dust to one pound of powder well mixed; having filled many of these quills, you shall place them in the same place as I taught you to put the powder and Stars, first putting a small quantity of Pistol powder under them, to blow them out when the Rocket is spent: upon this put your quills, as many as will fill the top of the case, with the open end downwards; so soon as the Rocket is spent, you shall see appear a golden showre, which by some is called golden Rain: The like way you may make silver Rain, filling the quills with the Composition for white Stars.

CHAP. VIII.

How to make Fisgigs, which some call by the name of Serpents, and to use them.

YOu must provide a small rouling pin, about one quarter of an inch in thickness, upon which roul seven or eight thicknesses of paper: fill them four inches with powder dust, sometimes putting between the filling a little of the Composition for Rockets of 10 ounces: and at the end of four inches choak him; fill two inches more with

with Piſtol powder; then choak the end up: at the other end put in a little of the mixture for Stars, and choak between that and the compoſition, and you have done: put divers of theſe with the Starry end downwards, upon the head of a Rocket, as you did the quills, with powder to blow them out; when the Rocket is ſpent, they will firſt appear like ſo many Stars; when the Stars are ſpent, taking hold of the powder duſt, they will run wrigling to and fro like Serpents; and when that Compoſition is ſpent, they will end with every one a report, which will give great content. I ſhall have occaſion to ſpeak of theſe Fiſgigs in other Fire-works.

CHAP. IX.

How to make Girondels, or (as ſome call them) Fire-Wheels.

A Fire-Wheel is often required in great Works for pleaſure, and therefore I have thought fit and neceſſary, to ſet down their deſcription, as well as of all other ſorts of Fire-works; Firſt, you muſt make a Wheel of Wood, ſo big as you pleaſe, to make Girondels, and unto theſe bind Rockets very faſt of a mean bigneſs, with the mouth of one towards the tail of another, thus continuing until you have filled your Wheel quite round, which done, cover them with paper paſted very curiouſly, that one taking fire, they may not take fire all together; and daub Sope upon them quite round, leaving the mouth of one of them open to give fire thereto; for the firſt Rocket having burned, will give fire to the next, keeping the Wheel in continual motion, until they be all ſpent: there may be bound fire Lances to theſe Girondels, either upright, or neer, overthwart, which will make to appear diverſity of fiery Circles; Your care muſt be, to place the Girondels at a convenient diſtance, from other Fire-Works, leſt they ſhould cauſe confuſion, and ſpoil all your Work.

CHAP. X.

How to repreſent divers ſorts of Figures in the Air with Rockets.

I Have taught you to make a report upon the head of a Rocket, and alſo to place golden or ſilver Hair or Rain, or Stars, or Fiſgigs, which when you have divers Rockets to make for a great Fire-work, let one be with a report, the next with Stars, another with Gold Hair, or Rain, one with Silver Hair or Rain, for ſtanding juſt under the Rocket it appeareth like Rain, but being aſide hand, like Golden or Silver Hair: and upon the head of another Rocket place the Fiſgigs, which when the Rocket is ſpent will firſt appear like ſo many Stars, after they are ended, they will ſhew like Serpents wrigling to and fro, and laſtly, give every one his report.

It is a rare thing to repreſent a Tree or Fountain, in the air, which is made by putting many little Rockets upon one great one, paſſing all the rods of the little ones

which now you must leave out to place in these Stars; after this manner make two or three holes in that pastboard, which prime with powder-dust: and thereupon put a little Pistol powder, to blow the Stars out when the Rocket is spent: after the powder, put as I have said before, the open ends of these Stars, down upon that powder: when you have put them so close as they can stick one by the other, put a little small corned powder on the top of them, to run between them, and put another tyre of Stars upon that, and in like manner a third tyre upon them, till you come to the top of the Rocket-case, there put a paper over the head of it, and tye it close about the top, that none of the powder come from under or between the Stars.

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CHAP. X.

How to repreſent divers ſorts of Figures in the Air with Rockets.

I Have taught you to make a report upon the head of a Rocket, and alſo to place golden or ſilver Hair or Rain, or Stars, or Fiſgigs, which when you have divers Rockets to make for a great Fire-work, let one be with a report, the next with Stars, another with Gold Hair, or Rain, one with Silver Hair or Rain, for ſtanding faſt under the Rocket it appeareth like Rain, but being aſide hand, like Golden or Silver Hair: and upon the head of another Rocket place the Fiſgigs, which when the Rocket is ſpent will firſt appear like ſo many Stars, after they are ended, they will ſhew like Serpents wrigling to and fro, and laſtly, give every one his report.

It is a rare thing to repreſent a Tree or Fountain, in the air, which is made by putting many little Rockets upon one great one, paſſing all the rods of the little ones

thorow wires, made on purpose upon the sides of the great one, or some other way, as your industry will discover; now if the little ones take fire while the great one is mounting up, they will represent a Tree, but if they take fire as the great one is descending or turning down again towards the ground, then they will be like a fountain of fire; if there be two or three little Rockets amongst others, that have no rods, they will make divers motions contrary to the rest, very pleasing.

If before you put the Fifgigs upon the head of a great Rocket, you with a small string tye them together, a foot of line between; when they are on fire in the Air you will see very great variety of Figures, because as they wriggle to and fro, they will pull one another after them, to the speculators great content: it will be pleasant if you tye them not altogether, but three or four, which will in the firing of them, be distinguished from the rest, with great variety.

CHAP. XI.

How to make a Rocket, which firing it out of your hand, shall continually be in agitation, either on the earth, or in the air.

HAving prepared a Rocket with a report in the head, such as I taught you first to make, tye it to a bladder, so that the end of the Rocket may come to the mouth of the said bladder, and bind it over very strongly, then firing it out of your hand, cast it away from you, it matters not which way, so it will come to the ground; there, by reason of the bladder, it cannot stay, but presently rebounds upwards, moving to and fro, until all be spent: there is another sort, and that is a small rocket, put into a bladder, and so blown up round about it, and tyed about the neck thereof, which will have delightful motions.

CHAP. XII.

Of the many defects in Fuzees, how they may be avoided, and of such things as ought to be observed in their good Construction.

THe first and most notable defect which is observed in Fuzees, is that after they are lighted or risen into the Air the height of 1, 2, or 3 Perches, they break, and do dissipate without making their entire effects.

The second, which is little better, is after it is remaining suspended upon the nail it consumes but very leisurely, without going away or raising it self in the Air.

The third is, when they are raised in the Air they describe only an Arch of a Circle like a Rainbow, and return upon the earth again before the Composition in the Fuzee be consumed.

The

The fourth is when it moves in a ſpiral manner, whirling in the Air without obſerving an equal motion; that is not right as it ought to be.

The fifth is when it mounts floathfully and negligently, as if it diſdained or refuſed to elevate it ſelf into the Air.

The ſixth and laſt is, that the Caſe or Cartouch remains hanging upon the Nail quite empty, and the Compoſition doth riſe and diſſipate alone into the Air. There is many other vexations and inconveniencies which may give trouble to the Practitioners in theſe Arts with vain expence, which would looſe too much time to repeat: It will be ſufficient if you take notice of theſe which are principal, whereby, if by ill fortune you be faln into any of theſe defaults, you may correct your error eaſily, and then immediately correct thoſe faults. And for this purpoſe, obſerve the rules given in the next Chapter.

CHAP. XIII.

Infallible Rules by which you may make Fuzees, or Rockets, without any default.

FIrſt, that they have their height proportionable to the Diameter of their Orifice, as we have before declared.

Secondly, the Cartouch ought to be of wood, or glued or paſted paper, not too thick, nor too thin.

Thirdly, they ought to be made of ſtrong paper of indifferent dryneſs, properly rouled and well compacted cloſe upon the Former.

Fourthly, the necks ought to be bound about very ſtrongly and firm, in ſuch a ſort, that the knot of the thred, and the folds of the Cartouch, may not lye amiſs one upon the other.

Fifthly, all the Materials of the Compoſition muſt be exactly weighed according to the proportion of the Orifice of the Fuzee that you would charge, and alſo well beaten and ſifted particularly; after, having weighed them again, and mixed them in one body well together, you muſt pound them again, and paſs them through the Sieve as you did before.

Sixthly, that the Salt-Peter and Sulphur be powdered and clarified as much as poſſible may be, and the Coal perfectly well burned and exempted from all humidity, and made of wood that is light and ſoft, as the Teile, the Hazle, and the branches of the Willow Tree; and on the contrary, 'tis neceſſary to have a care, that you make not uſe of ſuch Coals as are made of Birch, Oak, nor Maple, becauſe they contain in them much weighty and terreſtial matter.

Seventhly, matters for Rockets or Fuzees ought to be prepared immediately before they are intended for uſe, and not before.

Eighthly, the matters of Compoſition ought to be neither too dry nor too moiſt, but moiſtned a little with ſome Oliganious matter, or with a little Brandywine.

Ninthly, there muſt be put into the Cartouch alwayes an equal quantity of the Compoſition at a time, and ſo beat it down alike; and thus do until it be filled.

Tenthly, you muſt beat the Compoſition alwayes with the Rammer right up, or perpendicularly, and take care that in the beating it be not made crooked.

Eleventhly, You muſt ſtrike down the Compoſition with a wooden Mallet, that is of heft proportionable to the bigneſs and thickneſs of the Rocket, and alwayes with an equal ſtrength, and juſt number of ſtroaks, every time you put in any of the Compoſition.

Twelfthly, in Carrouches made of paper, you must put in round peeces of wood hollowed; but in those that are made of wood, you must put such as are smooth, without any channel or hollowing, to the end that it joyn the better to the sides of the Fuzee, where it must joyn firmly, as well without as within.

13. The Fuzee must be peirced with a Bit or Awl that is convenient, in such a sort that the hole be not too big nor too straight, nor too long nor too short.

14. The hole must be made the most streight and perpendicular that may be possible, and just in the middle of the Composition, to the end that it lean not to any one side, more than to the other.

15. The Fuzee must not be peirced before it be intended for use, and after it is peirced you must handle it tenderly, only with the ends of your fingers, for fear of deforming it.

16. The Pearch or Stick to which you fasten the Fuzee, ought to be proportionable as well in length as weight; it must not be crooked nor winding in any manner, neither unequal, nor full of knots, but streight as possible can be made, and must therefore be made smooth, and streightned with a Plain, if need requires.

17. After they are Charged, they must not be laid into too dry a place, nor in a place too moist, for the one or other of those accidents may hurt them; therefore let the place be temperate.

18. When you would use them and put them into action, hang them upon a nail perpendicular to the Horizon.

19. You must not think to raise a bundle of a great weight, or that has too great a disproportion to their strength, you must adjoyn them together so rightly, that all together may have a proper form, and reasonable to pass into the Air, and to elevate it self on high without any difficulty, and in such a sort, that those bundles may not by any means give hinderance or stoppage to their rising in a streight line; and take care most exactly that the Fuzee be not so big, but that they may retain as near as you can a Pyramidal or Conical form, when all its weight that may be is adjoyned to it.

20. Men ought to shun as much as possible those nights that are rainy, moist, and when the Sky is darkned with black clouds, as being very incommodious and offensive to the Fuzees. And more than that, avoid impetuous Stormy winds, and the Whirl-winds hinder no less than the first.

21. You may not reject above other causes, the different effects which are produced by sundry Fuzees (although they be charged with one and the same Composition) no otherwise than thus, that they were not made with an equal diligence either in the Charging or Peircing, or in the other Circumstances, which you were obliged to observe; or in this, that it may be some may have been kept in a more moister place than the others, where they have acquired too much moisture, which causeth to them, effects much different one from another, as well in Rising as in Consuming.

22. If you would make appear in the Air streams of fire, or a quantity of burning sparks or stars, or long large rayes to dart from the Fuzees; there is accustomed to mix with the Composition some small quantity of powdered Glass grosly beaten, filings of Iron, Sawdust. One may also represent fire of divers colours, as we have shewed before in the fifth Chapter; but more particularly thus; if you put a certain portion of Camphire in your Composition, you will see in the Air a certain fire which will appear, white, pale, and of the colour of Milk; if you put Greek Pitch, which is a light yellow Pitch used in Plaisters, called *Pix Burgundy*, it will represent unto you a red flame, and of the colour of Brass; if you put in Sulphur, the fire will appear blew; if Sal-Armoniack, the fire will appear Greenish; if from Crude Antimony, the flame will be Red, Yellowish, and of the Colour of Honey; if the filings of Ivory be added, they will render a Silver-like, White and shining flame, yet something inclining to a Livid Plumbous colour; if the powder of Yellow Amber be added, the fire will appear of the same colour, with the Citrine; lastly, if black Pitch be added, it will throw forth an obscure smoaky fire, or rather a smoak that is black and thick, which will darken all the Air.

CHAP.

CHAP. XIV.

Of Odoriferous Aquatick Balls.

CAuse to be made by a Turner, Balls of wood, hollow within, about the bigneſs of a Wild Apple, which you muſt fill with ſome one of theſe Compoſitions hereunto annexed, and they being all prepared and charged, you may throw them into the water after they are lighted, but it ought to be done in a Chamber or cloſe place, that the fume may be the better kept together, and this muſt be done with ſome ſmall end of our Match made of prepared Flax or Hemp, to the end that the Compoſition which is ſhut up in the Globe may take fire with the greater facility.

The Compoſitions are theſe that follow, viz.

Take Salt-Peter, Storax Calamite, one Dram; Incenſe one ounce, Maſtick one ounce, Amber half an ounce, Civet half an ounce, of the Sawings of Juniper wood two ounces, of the Sawings of Cypreſs wood two ounces, Oyl of Spike one ounce; Make your Compoſition according to the Art and Method given. Or,

Take of Salt-Peter two ounces; of Flower of Brimſtone, Camphire, half an ounce; powder of yellow Amber half an ounce, Coals of the Teile tree one ounce; Flower of *Benjamin*, or Aſſa ſweet, half an ounce; Let the matters that may be beaten be powdered, afterwards well mingled and incorporated together.

CHAP. XV.

Compoſitions to Charge Globes or Balls, that will burn as well under as above Water.

FIrſt, take Salt-Peter reduced into fine meal 16 *l.* Sulphur 4 *l.* of the ſawings of wood which hath been firſt boyled in a Nitrous water, and afterwards well dryed, 4 *l.* Of good Corned powder half a pound, of the powder of Ivory 4 ounces. Or thus,

Salt-Peter 6 *l.* Sulphur 3 *l.* of beaten powder 1 *l.* Filings of Iron 2 *l.* of Burgundy pitch half a pound. Or thus,

Salt-Peter 24 *l.* of beaten powder 4 l. Sulphur 12 *l.* of Sawduſt 8 *l.* of yellow Amber half a pound, of Glaſs beaten in groſs powder half a pound, of Camphire half a pound. For that which concerns the manner of preparing all theſe Compoſitions; it differs nothing from what we have preſcribed in the making of Rockets, only 'tis not neceſſary that the materials be ſo ſubtilly beaten, powdered nor ſifted, as for thoſe *Fuzees*; but nevertheleſs to be well mixed one among another. Care muſt be taken that they be not too dry when you charge the Globes or Balls, and for that purpoſe they may be moiſtned with Linſeed-oyl, Oyl of Olives, Petrole, Hempſeed, Nuts, or any other fatty humour that is receptible of fire.

Note, that amongſt all theſe Compoſitions of matters that will burn in the water, which I have here propoſed from my own particular experience, every one may make them as pleaſeth himſelf beſt, provided he always take the materials in propor-

tion one to the other, as they ought. But nevertheleſs I ſhall counſel you to experience from time to time your Compoſitions, for the greater ſurety, before you expoſe them to the publick view of the world. It is alſo amongſt the reſt very neceſſary that you learn the force and ſtrength of every material you put into the Compoſitions, whereby you may at your pleaſure know how to alter and vary your proportion, as you ſhall judg fit.

CHAP. XVI.

Of Stars and fiery Sparks, called by the Germans Stern-veuer and Veuerputzen.

I Have ſhewed the Compoſition of Stars in Chap. 5. I have alſo ſhewed the way of making them up, and their uſe, and alſo I have ſhewed the manner of giving to them various Colours, as in the 22 Rule of the 13 Chapter, where I had an intent to ſay no more of theſe things: But finding in Maſter *Cazimier*'s Artillery theſe Compoſitions, which I judge may prove very excellent; therefore I thought good to inſert them, that I might leave out nothing that might make more perfect any thing we treat of.

Firſt, you muſt know that between fiery Sparks and Stars there is this difference, that the Stars are greater, and are not ſo ſoon conſumed by the fire as the Sparks are, but do ſubſiſt longer in the Air; and do ſhine with greater ſubſtance, and with ſuch a light, that by reaſon of their great ſplendor, they are in ſome manner comparable with the Stars in the Heavens. They are prepared according to the following Method.

Take Salt-Peter half a pound, Sulphur two ounces, Yellow Amber powdered one Dram, Antimony Crude one Dram, of beaten Powder three Drams. Or,

Take Sulphur two ounces and a half, Salt-Peter four ounces, Powder ſubtilly powdered four ounces, Olibanum, Maſtick, Chriſtal, Mercury ſublimate, of each four ounces, White Amber one ounce, Camphire one ounce, Antimony and Orpiment half an ounce; All theſe materials being well beaten and well ſifted, they muſt be mixt together with a little Glue or Gum-water, made with Gum-Arabick or Tragacant; then make them into ſmall Balls about the bigneſs of a Bean or ſmall Nut, which being dryed in the Sun, or in a Pan by the fire, may be kept in a convenient place for ſuch uſes as we have ſpoken of in the fifth Chapter of this Book. You muſt only remember, that when you would put them into Rockets or Recreative Balls, they muſt be covered on all ſides with prepared Tow, of which we have ſhewed the way of preparing in the ſeventh Chapter of the firſt Part of our Fire-works.

Sometimes Fire-Maſters are accuſtomed to take in the places of theſe little Balls, a certain proportion of melted matters, of which we have ſpoken in the firſt Part of Fire-works; But if theſe do not pleaſe you, by reaſon of their ſwarthy colour, but you rather deſire to ſee them yellow, or inclining ſomewhat to white, then take of Gum-Arabick or Tragacant four ounces, powder it and paſs it through a Sieve, of Camphire diſſolved in *Aqua-vitæ* two ounces, Salt-Peter a pound and a half, Sulphur half a pound, Glaſs groſly powdered four ounces, White Amber an ounce and a half, Orpiment two ounces, make all theſe Ingredients into one maſs, and make Globes of them as before. I Learned this, ſaith my Author, from *Claude Midorge*.

For

For the method of making Sparkles in particular, it is thus; Take Salt-Peter one ounce, of this Liquid matter half an ounce, of beaten Powder half an ounce, of Camphire two ounces; after you have beaten all these materials into powder, every one by it self, put all of them into an Earthen Pan, and put upon them the Water of Gum Tragacanth, or Brandy-wine, wherein you have dissolved some Gum Tragacanth or Arabick, until it be of a good consistency; that done, take an ounce of Lint, which has first been boyled in Brandy-wine or Vinegar, or in Salt-Peter, and after dryed again, and the threads drawn out; then put it into the Composition, and mix them well together, so well and so long until it has drank up all the matter; of these Compositions make little Balls in the form of Pills, and of the bigness of great Peas, which you must roul in mealed Gun-powder, and dry them, whereof you may serve your self, according to the method we have prescribed.

Besides these, there are certain odoriferous Pills prepared, which are employed in small Engines and fiery Inventions, which are shewed in Chamber Roams, or close Cabinets, these are commonly prepared of Storax, Calamite, Benjamin, Amber, white and yellow, and of Camphire, of each one ounce, Salt-Peter three ounces, of Coals made of the Teil Tree four ounces; beat all these Ingredients to powder, then incorporate them well together, and moisten them with Rose Water, in which is dissolved Gum-Arabick or Tragacanth, to make thereof little Balls; at last, having fashioned them, expose them to the Sun or to the fire to dry.

THE DOCTRINE OF PROJECTS APPLYED TO GUNNERY.

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THE PREFACE.

GALILÆUS *in his 4th. Dialogue of Motion, hath largely treated of æquable and accelerate or increasing Motions, as also of that of Projects, or things shot, and thence derived several Propositions or Conclusions, and hath likewise made several Tables touching the Amplitudes or Base Lines, and the Altitudes or Heights of the* Semiparabola's *or* Curves *described by the Motion and Ranges of Projects. The which Doctrine the late Famous* Torricellio *of* Florence, *having with great Judgment much advanced and facilitated, applying the whole to the* Art of Gunnery; *that the benefit of his pains might redound to the* English *Reader, that is especially Delighted or Exercised in the Affairs of* Mars, *it was thought fit to render the same into* English.

THE PREFACE.



THE DOCTRINE OF PROJECTS APPLYED TO GUNNERY.

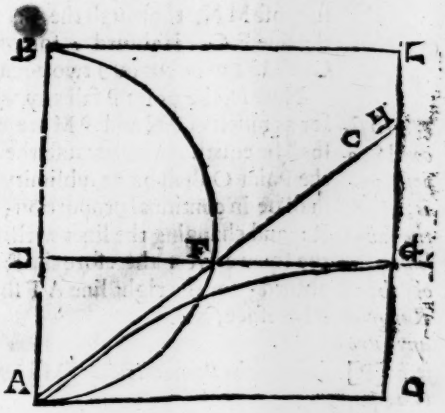
PROPOSITION.

The Impetus B A (that is, as much as is that of the moveable naturally falling from B to A by the * Definition) as also the Direction A I, according to which the Projection is to be made with the said Impetus being given: it is required to find the Amplitude, Altitude, and the whole future Parabola of this Projection.

* Which Definition is; *when we name an* Impetus *given, we determine it in spaces, according as* Galilaus *useth*; Exemp. Grat. When we say, let the *Impetus* given be A B, then we mean, let the *Impetus* given be so much as is requisite to throw the Project from A to the highest point of the perpendicular B; or, which is the same, as much as is the *Impetus* of a moveable naturally falling from B to A.



Horow A and B draw the Horizontal lines A D, and B L, and describe the Semicircle A F B about the Diameter A B, which shall somewhere cut the line A C, seeing that A D is a Tangent. Let the Section be in F, and draw the Horizontal line F E, and prolong F G equal to F E; then by G let fall the perpendicular L G D; then about the Diameter G D, by the points G and A, describe the *Parabola* A G, which can be but one, by the precedent * *Lemma*; nor can there any other *Parabola* be described about the Diameter



* *Which* Lemma *was*; *that about the Diameter* G D, *thorough the* Vertex G, *and any assigned point* A, *there cannot be described more than one* Parabola. *Lemm. of Propos. VIII.*

this is the *Parabola* ſought. For the directive line of this *Parabola* is A I, ſeeing that it toucheth the *Parabola* in A, for E G, or A D, is double to F G by conſtruction; and therefore D G, and G I are equal: wherefore A I is the Tangent to the *Parabola*.

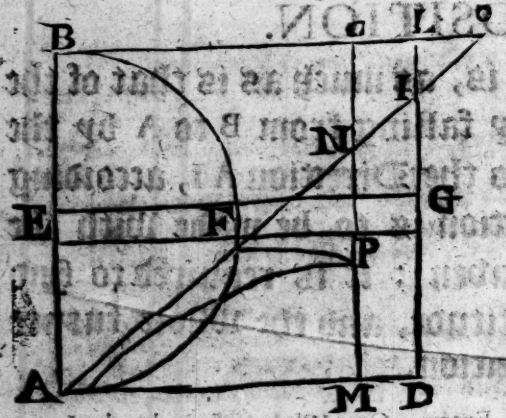
De motu Projectorum.

Again, I ſay, that this *Parabola* is deſcribed by the *Impetus* given; for A E, E F, and E B, or thoſe three lines equal to D G the Altitude, G F the Semi-baſe, and G L are in continual proportion. Wherefore G L is the ſublimity, by the V. Propoſition of * *Galilæus*, and its Corollary.

Then thus: the *Impetus* of the *Parabola* A G in the point A, is as much as that of the Cadent naturally falling from I to D, (by X. of *Galilæus*) that is, from B to A, or of the Project aſcending from A to B: therefore the *Parabola* hath in the point A the *Impetus* that was given: wherefore that is done which was required.

But becauſe this Propoſition is of great moment, for clearing of thoſe that follow, we will prove it another way.

Let the ſame *Impetus* A B, and the ſame direction A F C be given: the *Parabola* made by this projection is ſought, deſcribe as before, a Semicircle about the Diameter A B, which ſhall cut A C: ſeeing that A D is a Tangent. Let it cut it in F, and drawing the Horizontal line E F G, ſo as that E F and F G may be equal, deſcribe, or conceive a *Parabola* to be deſcribed along by the points A and G about the Diameter G D. I ſay, that this is the *Parabola* of the Project, if it be thrown from the point A, according to the Direction A C, with the *Impetus* A B. Now if the moveable do not run along this ſame *Parabola* it will run along ſome other; as ſuppoſe A P: let the Vertex, or the higheſt point of this *Parabola* A P be found, and let it be P.



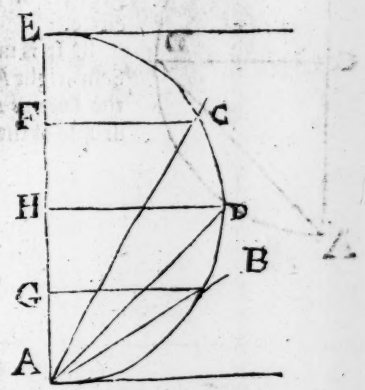
Firſt, it is manifeſt that the point P cannot be in the line L D; becauſe ſince the line A C toucheth each *Parabola*, that I D the common *Axis* ſhould be cut into two equal parts in two points by the Vertex's of the *Parabola*, is abſurd. Nor can it be in the line E G: for drawing the Diameter, ſuppoſe M N, thorough the Vertex, that M N ſhould be cut into two equal parts by the line E G, is abſurd: for only I D, of all the lines parallel unto it in the angle C A D, can be cut into two equal parts.

Which ſecond Propoſition is, that the ſublime point of the Range of any Project [P] *doth cut the Perpendicular* [M] *intercepted betwixt the Horizon and line of direction, into two equal parts.*

Now let the point P fall any where at pleaſure, and draw the Horizontal line P R S: for as much as P N and P M are equal, by the II of * this, N R and R A, P R and R S ſhall be equal. And becauſe the *Parabola* A P hath the *Impetus* B A; that is, O M, the Point O ſhall be its ſublimity: and for that reaſon the lines O P, P R, and P M ſhall be in continual proportion; and the Rectangle O P M equal unto the ſquare P R: and changing the lines with their equals, the Rectangle B S A ſhall be equal to the ſquare S R: therefore the R is in the point Periphery of the Semicircle: which is abſurd; for the right line A F ſhall meet with the Periphery in two ſeveral points: wherefore, &c.

COROLLARIES.

COROLLARIES.



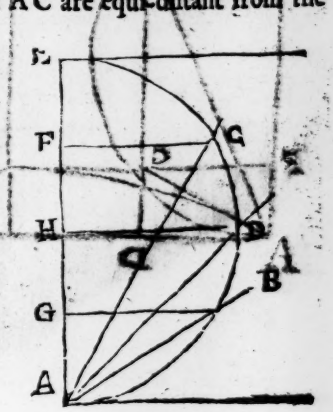
First, Hence is manifeſt, that the *Impetus* of any Machine being given, as for example E A, if there be deſcribed about E A the Semicircle A D E, one may aſſign the Altitudes and the Amplitudes of all the projections that can be made by the ſame Machine. For example; the *Impetus* E A remaining ſtill the ſame, let projections be made along the lines of ſeveral elevations A C, A D, and A B. The projection made according to the direction A C, ſhall aſcend as high as to the Horizontal line F C prolonged: and the projection made along the direction A D, ſhall have its Apex in the line H D prolonged: and of the projection made according to the line A B, the greateſt Altitude ſhall be in the Horizontal line G B prolonged.

2. In the Book of *Galilæus de motu naturaliter accelerato*, it is proved, that projects thrown with the ſame *Impetus* out of A, if born up by plains of ſeveral inclinations, do alwayes arrive unto one and the ſame Horizontal plain. But here it appeareth, that the ſeveral aſcenſions of projects do vary when they are thrown thorough the pure Air, without any fulciment put under them, according to ſeveral elevations. For the moveable ſhall leſs aſcend, which is emitted along the line A B leſs elevated, than that which ſhall be projected along A D more elevated.

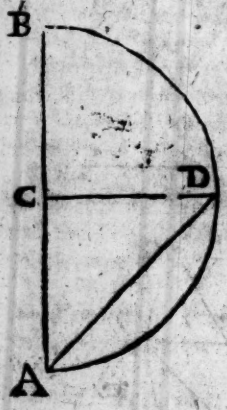
3. It is manifeſt alſo, that no Altitude can in ſuch ſort aſcend, as that it may reach unto the Horizontal parallel that is drawn thorow E the higheſt point of the perpendicular projection.

4. It is alſo manifeſt, that all Amplitudes do alwayes encreaſe from that projection which is called the point blanck Randon, until you come to the projection made at the Semi-right Angle. And from the Semi-right unto the perpendicular, they alwayes diminiſh until they come to nothing; which happeneth in the perpendicular projection, which hath no Amplitude.

5. From whence we may obſerve, that the Amplitudes of each *Parabola* made by the ſame *Impetus*, the elevations of which are equi-diſtant from the Semi-right, are equal to each other. For, ſince the lines A B and A C are equi-diſtant from the Semi-right elevation, the Arches D B and D C ſhall be equal, as ſubtending equal Angles: and conſequently the B A and C E, the remainders of their Quadrants ſhall be equal: therefore alſo the Sines of them, B G and C F, ſhall be equal. And for the ſame reaſon, the whole Amplitudes of each *Parabola*, which are Quadruple to the Sines B G and C F, ſhall be equal.



6. It is manifeſt likewiſe that the Altitudes and Sublimities of projections equi-diſtant from the Semi-right, are reciprocally equal to one another, that is, the Altitude of the one is equal to the ſublimity of the other.



* *Or Random.*

7. We will therefore make a Corollary of that which to *Galilæus* was an arduous Theorem, to wit, that the Semi-right * projection is the greateſt of all thoſe made by the ſame *Impetus*. For, if you ſuppoſe the Angle C A D to be Semi-right, C D ſhall be the Semi-Diameter; that is the greateſt of all the Sines that can be given in the Semi-circle.

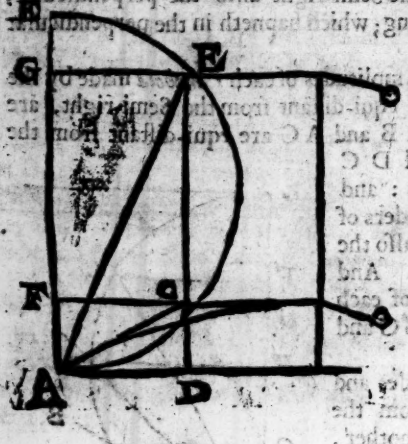
8. It is manifeſt alſo, that the whole Amplitude of the Semi-right *Parabola* is double to the line of the Sublimity, or the *Impetus* A B: for it hath been demonſtrated to be Quadruple of the right line C D, that is double to A B.

PROP. II.

I incite this Propoſition, as being alſo cited in the enſuing Diſcourſe.

The Impetus and Amplitude being given, to find the direction according to which the Parabola was made; as alſo to find the Altitude.

LEt the given *Impetus* be A B, and let A D be the fourth part of the Amplitude given. About A B deſcribe the Semi-circle A C B, and erect D C E, (which if it ſhall not fall in the Semi-circle, the Problem is impoſſible) and let it cut the Semi-circle in the points C and E. I ſay, that either the direction A C or A E, if the given *Impetus* A B be retained, ſhall deſcribe a *Parabola*, whoſe Amplitude ſhall be Quadruple to the line A D, this is manifeſt from the things preceding. For projections made with the *Impetus* A B, according to the directions A C, or A E, have an Amplitude Quadruple to G E, or F C or A D, which are equal to one another; and the Altitude may in the one be A F, as alſo in the other A G, as appeareth, *&c.*



In

In this place I have thought fit to insert the Tables following: the first Classis of which containeth three Tables, the same with those of *Galilæus*, which we placed *Part. I. Dial. 4. Page* 241. of this present Tome, but different in many of the Numbers, as being defumed from the Tables of Sines and Tangents, whereas *Galilæus* Calculateth his with much labour, according to the Principles of his Doctrine of Projective motion, laid down in that his fourth Dialogue. The second Classis consists of two Tables added by *Torricellius*, the one of Durations, the other of Elevations or Randons: the Explanations and Calculations of which are annexed to them by the Author, but here omitted on the account of brevity.

TABLE I.

The Amplitudes of the *Semi-Parabola's* described by the same *Impetus*. The greatest Amplitude is supposed to be of 10000 parts, and the Numbers of the Table are double to the right Sines of the arches of the elevation.

Degr. of Elevat.	*Ampl. of Semi-P.*	*D. of Elev.*
1	349	89
2	098	88
3	1045	87
4	1392	86
5	1736	85
6	2079	84
7	2419	83
8	2756	82
9	3090	81
10	3420	80
11	3746	79
12	4067	78
13	4384	77
14	4695	76
15	5000	75
16	5299	74
17	5592	73
18	5870	72
19	6157	71
20	6428	70
21	6691	69
22	6947	68
23	7193	67
24	7431	66
25	7660	65
26	7880	64
27	8090	63
28	8290	62
29	8480	61
30	8660	60
31	8829	59
32	8988	58
33	9135	57
34	9272	56
35	9397	55
36	9511	54
37	9613	53
38	9703	52
39	9781	51
40	9848	50
41	9903	49
42	9945	48
43	9976	47
44	9994	46
45	10000	45

TABLE II.

The Altitudes of the *Semi-Parabola's*, whose *Impetus* is the same with that of the precedent Table. The greatest Altitude is supposed to be of 10000 parts, and the Numbers of the Table are double to the halfs of the versed Sines of the Arches of the Elevation.

D. of Elev.	*Altit. of Semi-P.*	*D. of Elev.*	*Altit. of Semi-P.*
1	3	46	5174
2	12	47	5349
3	27	48	5523
4	49	49	5696
5	76	50	5868
6	109	51	6040
7	149	52	6210
8	194	53	6378
9	245	54	6545
10	302	55	6710
11	364	56	6873
12	432	57	7034
13	506	58	7192
14	585	59	7347
15	670	60	7500
16	760	61	7650
17	855	62	7796
18	955	63	7939
19	1060	64	8078
20	1170	65	8214
21	1284	66	8346
22	1403	67	8470
23	1527	68	8597
24	1654	69	8716
25	1786	70	8830
26	1922	71	8940
27	2061	72	9045
28	2204	73	9145
29	2350	74	9240
30	2500	75	9330
31	2653	76	9415
32	2808	77	9494
33	2966	78	9568
34	3127	79	9636
35	3290	80	9698
36	3455	81	9755
37	3622	82	9806
38	3790	83	9851
39	3960	84	9891
40	4132	85	9924
41	4304	86	9951
42	4477	87	9973
43	4651	88	9988
44	4826	89	9997
45	5000	90	10000

TABLE III.

The Altitudes and Sublimities of the *Semi-Parabola's*, whose Amplitudes are equal, *Viz.* alwayes 10000 parts; the Altitudes are the halfs of the Tangents of the Angles of the Elevation; and the Sublimities are the halfs of the Tangents of the Complements of the Elevation.

D. of Elev.	*Altitudes.*	*Sublimities.*	*D. of Elev.*	*Altitudes.*	*Sublimities.*
1	87	286450	46	5178	4828
2	175	143186	47	5362	4663
3	262	95406	48	5553	4502
4	350	71503	49	5752	4346
5	437	57150	50	5959	4196
6	525	47572	51	6175	4049
7	614	40722	52	6400	3906
8	703	35577	53	6635	3768
9	792	31569	54	6882	3633
10	882	28356	55	7141	3501
11	972	25723	56	7413	3373
12	1063	23523	57	7699	3247
13	1154	21657	58	8002	3124
14	1247	20054	59	8321	3004
15	1340	18660	60	8660	2887
16	1434	17437	61	9021	2772
17	1529	16354	62	9404	2659
18	1625	15388	63	9813	2548
19	1722	14521	64	10252	2439
20	1820	13737	65	10723	2332
21	1919	13025	66	11230	2226
22	2020	12375	67	11779	2122
23	2122	11779	68	12375	2020
24	2226	11230	69	13025	1919
25	2332	10723	70	13737	1820
26	2439	10252	71	14521	1722
27	2548	9813	72	15388	1625
28	2659	9404	73	16354	1529
29	2772	9020	74	17437	1434
30	2887	8668	75	18660	1340
31	3004	8321	76	20054	1247
32	3124	8002	77	21657	1154
33	3247	7699	78	23523	1063
34	3373	7413	79	25723	972
35	3501	7141	80	28356	882
36	3633	6882	81	31569	792
37	3768	6635	82	35577	703
38	3906	6400	83	40722	614
39	4049	6175	84	47572	525
40	4196	5959	85	57150	437
41	4346	5752	86	71503	350
42	4502	5553	87	95406	262
43	4663	5362	88	143186	175
44	4828	5718	89	286450	87
45	5000	5000	90	*Infinita.*	00

TABLE IV.

The Durations or *Impetus* of Projects made by the ſame *Impetus* compared to the Horizon. The greateſt Duration or *Impetus* is ſuppoſed to be of 1000 parts; and the Numbers of the Table are the right Sines of the Elevations.

Degr. of Elevat.	*Dur. or Impet.*	*D. of Elev.*	*Dur. or Impet.*
1	75	46	7193
2	349	47	7314
3	523	48	7431
4	698	49	7547
5	872	50	7660
6	1045	51	7771
7	1219	52	7880
8	1392	53	7986
9	1564	54	8090
10	1736	55	8192
11	1908	56	8290
12	2079	57	8387
13	2250	58	8480
14	2419	59	8572
15	2588	60	8660
16	2756	61	8746
17	2924	62	8892
18	2090	63	8910
19	3256	64	8988
20	3420	65	9063
21	3584	66	9135
22	3746	67	9205
23	3907	68	9272
24	4067	69	9336
25	4226	70	9397
26	4384	71	9455
27	4540	72	9510
28	4695	73	9563
29	4848	74	9613
30	5000	75	9659
31	5150	76	9703
32	5299	77	9744
33	5446	78	9781
34	5592	79	9816
35	5736	80	9848
36	5878	81	9878
37	6018	82	9903
38	6157	83	9925
39	6293	84	9945
40	6428	85	9962
41	6561	86	9976
42	6691	87	9986
43	6820	88	9994
44	6947	89	9998
45	7071	90	10000

TABLE V.

The Degrees of Elevation to which the Piece is to be mounted, that the Amplitude of the Projections may be made of the given meaſure. We ſuppoſe all the Projection to have the ſame *Impet.* that is to be made by the ſame Piece, & that the greateſt is 4000 paces.

Spaces.	*Deg. of Elevat.*	*Complement.*
100	1 7	89 43
200	2 0	89 26
300	2 52	89 08
400	3 09	88 51
500	3 26	88 34
600	3 43	88 17
700	4 00	88 00
800	4 18	87 42
900	4 35	87 25
1000	4 52	87 08
1100	5 09	86 51
1200	5 27	86 33
1300	5 44	86 16
1400	6 01	85 59
1500	6 19	85 41
1600	6 36	85 24
1700	6 54	85 06
1800	7 11	84 49
1900	7 29	84 31
2000	7 46	84 14
2100	8 04	83 56
2200	8 21	83 39
2300	8 39	83 21
2400	8 57	83 03
2500	9 14	82 46
2600	9 32	82 28
2700	9 50	82 10
2800	10 08	81 52
2900	10 26	81 34
3000	10 44	81 16
3100	11 02	80 58
3200	11 20	80 40
3300	11 38	80 22
3400	11 56	80 04
3500	12 14	79 46
3600	12 33	79 27
3700	12 51	79 09
3800	13 10	78 50
3900	13 29	78 31
4000	13 47	78 13
4100	14 06	77 54
4200	14 25	77 35
4300	14 44	77 16
4400	15 03	76 57
4500	15 22	76 38
4600	15 42	76 18
4700	16 01	75 59
4800	16 21	75 39
4900	16 40	75 20
5000	17 00	75 00
5100	17 20	74 40
5200	17 40	74 20
5300	18 00	74 00
5400	18 21	73 39
5500	18 41	73 19
5600	19 02	72 58
5700	19 23	72 37
5800	19 44	72 16
5900	20 05	71 55
6000	20 26	71 34
6100	20 48	71 12
6200	21 10	70 50
6300	21 32	70 26
6400	21 54	69 06
6500	22 16	69 44
6600	22 39	69 21
6700	23 02	68 58
6800	23 25	68 35
6900	23 49	68 21
7000	24 13	67 47
7100	24 37	67 23
7200	25 02	66 56
7300	25 27	66 33
7400	25 52	66 08
7500	26 18	65 42
7600	26 44	65 16
7700	27 11	64 49
7800	27 38	64 22
7900	28 06	63 54
8000	28 34	63 26
8100	29 03	62 57
8200	29 33	62 27
8300	30 03	61 57
8400	30 34	61 26
8500	31 06	60 54
8600	31 36	60 21
8700	32 14	59 46
8800	32 50	59 10
8900	33 27	58 33
9000	34 05	57 55
9100	34 45	57 15
9200	35 28	56 32
9300	36 13	55 47
9400	37 02	54 58
9500	37 54	54 06
9600	38 52	53 08
9700	39 58	52 02
9800	41 16	50 44
9900	42 57	49 03
10000	45 00	45 00

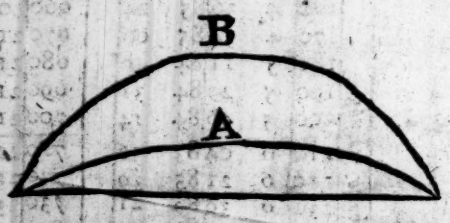
Spaces, or equidistances of the Projection.

The uſe of the Precedent

TABLE.

SUppoſe that the greateſt Range, namely the Range made at the elevation of the ſixth point of the *Quadrant* by a Culverin, be, for example, 4000 Geometrical paces, I deſire with the ſame Piece to make a ſhot in ſuch manner that its Range may be juſt 2360 paces long. I take the fourth part of 2360, which is 590, and I look upon the Table, and find againſt that Number, that the elevation to be given to the ſaid Piece is 18 Degrees and 5 Minutes, or Gr. 71. and Min. 55, its Complement. And I ſay, by the things demonſtrated, that the forementioned Piece with one of theſe two Elevations, ſhall carry the Ball 2360 paces diſtance above the Horizon. But thoſe Elevations which exceed the ſixth point of the *Quadrant*, are not inſerted for the uſe of * Artillery, but only for Morter-Pieces, Rams, and Granadoes. It is to be noted, therefore, that with that ſame firſt Elevation the Ball will make a low Range, but ſwift, as the line marked A, and with a great Horizontal *Impetus*, proper to make breaches in Walls, or give other lateral impulſes. But with the other Elevation it ſhall deſcribe the Range B, which ſhall be ſlow in its Horizontal motion, but with ſufficient perpendicular *Impetus* at the laſt, proper to batter Vaults, Roofs, and to make other breaches perpendicular to the Horizon; or to caſt things to any determinate mark, as, *v. gr.* little Baggs imbaled with Cord, full of Sulphur, Salt-Peeter, or Meal, or Balls with Letters or other things within them. In a word, both thoſe Elevations that are equally diſtant from the ſixth point, will carry the Ball unto the ſame place: but yet with this difference, that with the firſt and leaſt Elevation it ſhall fall to the Earth (as Gunners ſpeak) Grazing; and with the ſecond and greater Elevation, it ſhall deſcend almoſt plumb, or perpendicular.

That is, all long Pieces.



I know that its very ſeldom, and perhaps never found, that the greateſt Range of a Piece of Ordnance is juſt thoſe 4000 Paces, as it ſeemeth to have been ſuppoſed in the Calculating of our Table, and alſo in thoſe of *Signiore Galileo*, ſo that the ſaid Table might ſeem unuſeful: but we ſhall ſhew, that the ſuppoſed number of 4000 doth not therefore ſerve to any great particular Machine, to the end it might ſerve to all in general. It is neceſſary therefore to take notice, that that ſame ſuppoſitious Number of 4000, is not of Paces, or of Ells, or of Yards, or of any other determinate meaſure, but of abſtracted parts, ſuch yet, whatever they are, as being convertible into any kinds of poſſible meaſures, they do make the Table general, as well for the Culvering, as for the Mortar-Piece or Croſs-Bow. And to give an example how it may be adapted and applyed to all the Species of Artillery, and how the Abſtract parts may be reduced into Geometrical paces, we will do thus.

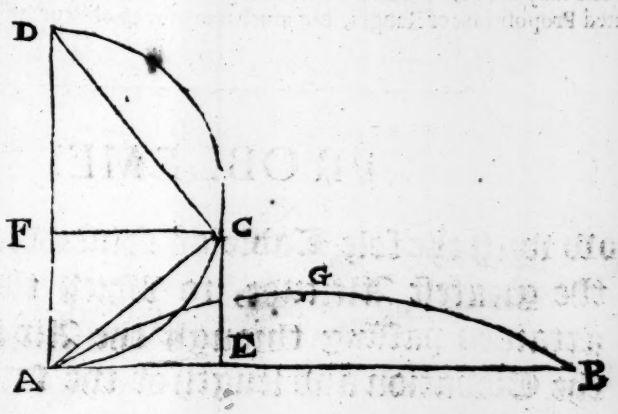
The greateſt Range of a Canon, by experiment made thereof, is found to be, ſuppoſe 2300 paces; and I would with the ſame Piece make a ſhot that ſhould be 860 paces, I do thus: If the greateſt Range 2300 give 860, I ask what the number 1000, the greateſt of the Table will give? I work and find 374: which number being ſought in the Table, is found to be betwixt 370 and 380. Therefore taking the part proportional according to my Judgement, I find the Arch of its Elevation ought to be *Grad.* 11. very near, or its Complement *gr.* 79. And thus it is certain,

tain, that that ſame Piece which being mounted to ſix points did carry 2300 paces, being elevated *gr.* 11. or 79. of the *Quadrant*, ſhall carry 860 paces, as we did deſire.

PROBLEME.

How by a Shot made caſually, one may find the greateſt Range of an Ordnance.

LEt a Piece be directed according to the Mounture A C; of which let the Elevation be the Angle B A C, whatever it is. And the ſaid Angle being meaſured with the *Quadrant*, let it be found; for example, *gr.* 30. then let off the Piece, and let the Shot reach to the point B: and let the line A B be carefully meaſured, which ſuppoſe to be *v. gr.* 2400 Geometrical Paces, I ſay that theſe two things being given, namely the Elevation, and the length of the caſual Range A G B, you have therewithal given the line A D, which is the half of the greateſt Range, according to what hath been demonſtrated in the laſt Corollary of the firſt Propoſition, *De Motu Projectorum.*



The Angle of Elevation C A B *gr.* 30, being given, the right Angled Triangle E A C ſhall be given in Specie: and becauſe A B is given in paces, A E ſhall be given, which is the fourth part thereof, namely 600 paces. Let us therefore, to find the quantity of A D, work in this manner by Calculations and Sines.

Say, if as the Right Sine 86602 of the Angle A C E, *gr.* 60. that is, of the Complement of the Elevation, is to the ſide A E, which is 600: ſo is the whole Sine 100000 to a fourth number 693: and thus the Hypothenuſe A C ſhall be 693 Paces. But becauſe that the right angled Triangle A C D is given in Specie, begin again and ſay, as the right Sine 50000 of the angle A D C, which is equal to the angle given of the Elevation E A C, is to the right Line A C, which is found to be 693 paces, ſo is the whole line to a fourth number 1386. And thus the right line ſought A D, ſhall be 1386 paces. But becauſe A D, being the line of *Impetus* or Sublimity, is equal to half the greateſt Range; if we double 1386, we ſhall make the number of 2772 paces; for ſo much ſhall be the length of the deſired greateſt Range of that Gun, which being elevated to the Randon of *gr.* 30, is found to carry 2400 paces.

But with much more brevity, and at one ſingle working, we may perform the ſame thus. Suppoſe the whole Sine to be C F, then F A and F D ſhall be the Tangents, one, of the angle of elevation, and the other of its Complement. Say, therefore, as the whole Sine is to C F, which is 600: ſo is 230940 (which is the

ſum of both thoſe Tangents) to a fourth number 1386. And thus the right line A D, is found, as before, 1386 paces: which being doubled, will give the meaſure of the Semirect, or greateſt * Randon, as you well call it.

Or the beſt of the Randon.

COROLLARIES.

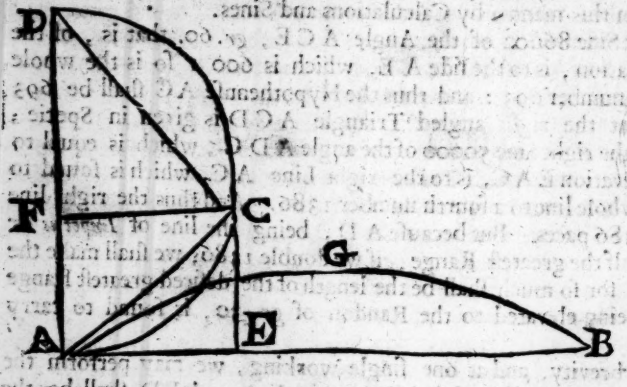
1. BY way of Corollary it may be advertiſed, that this is the manner of arguing from any Range of a Piece, how much the ſame ſhould be to ſhoot upwards by a perpendicular line; which ſhall be as much as the line A D found out by way of Calculation.

2. The ſame line A D, directs us from what Altitude it would be requiſite to let fall a Cannon Bullet, that it may arrive at the Earth with the ſame *Impetus* that the Cannon it ſelf conferreth, alwayes allowing for the impediment which the Craſſitude of the Air may occaſion, which acknowledge muſt be ſenſible for to vary the demonſtrated Propoſitions of Ranges, but much more for to obſtruct this effect.

PROBLEME.

How with the ſole Table of Sines we may know the greateſt Altitude, to which the Ball hath attained paſſing through the Air in a Range, the Elevation and length of the ſaid Range being given.

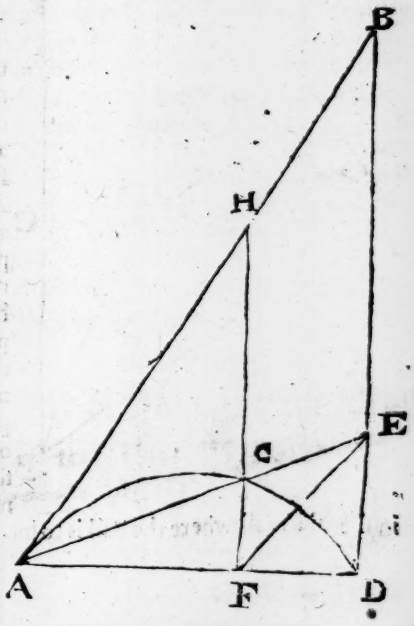
IN the precedent Figure, let there be given the angle of the Elevation C A B, and the length of the Range A B; it is required to know the greateſt Altitude to which the Ball hath arrived thorough the Air: and this ſhall be E C. Take again A E 600 paces, that is, the fourth part of the whole length A B: and then ſay, as 86602 the Sine of the Angle A C E, the Supplement of the Elevation, is to A E, 600 paces, ſo is 50000, the Sine of the Elevation E A C to a fourth number: and we ſhall find 346 paces for meaſure of the Altitude C E, that is, of the greateſt Altitude to which the Ball had attained in its paſſage through the Air.

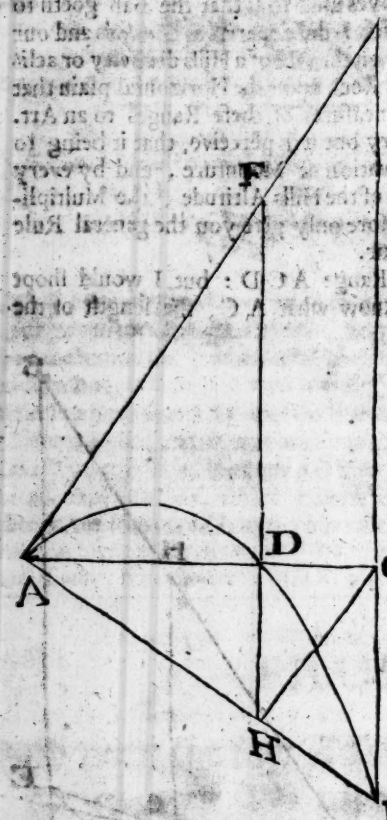


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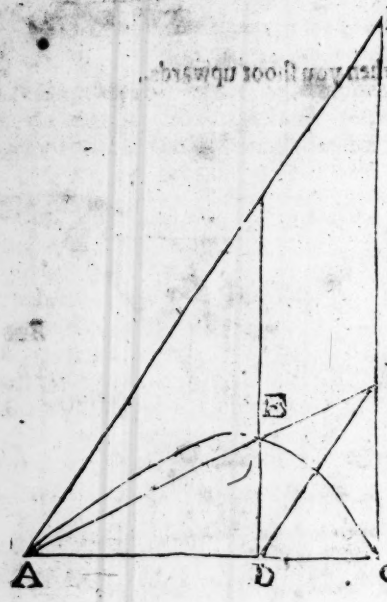
It is to be noted, that great Guns are not alwayes uſed ſo as that the Ball goeth to determine in the ſame Horizontal plain from which it did depart, as *Galileo*'s and our Tables do ſuppoſe. Therefore being to ſhoot upon the ſide of a Hills declivity or aclivity, as alſo being to ſhoot from the ſummity of a Rock upon the Horizontal plain that is below, there hath no man as yet reduced the meaſures of theſe Ranges to an Art. The Table of them might be calculated, but every one will perceive, that it being to be compoſed by every grade of the Pieces Elevation or Mounture, and by every grade of the Hills inclination, and by every pace of the Hills Altitude, the Multiplication would be almoſt infinite. We will therefore only give you the general Rule for calculating thoſe Ranges when they ſhall occur.

A Piece with the direction A B, maketh the Range A C D: but I would ſhoot along the inclined plain A C; and I deſire to know what A C, the length of the Range of that ſhot upon this plain, ſhall be. Draw B D by the point D, and H F by the point C, perpendiculars to the Horizon; and draw a line from F to E; which by the things demonſtrated, is parallel to A B. Meaſure with ſome Inſtrument the angle D A E, that is the Hills Elevation, and, by the Table of Amplitudes, you ſhall find the length of the Horizontal Range A D. Then ſay, as D B the Tangent of the angle of the Pieces, Elevation is to B E, which is the difference of the Tangents of the two angles D A B and D A E known, (one being the Elevation of the Piece, the other the Elevation of the Hill above the Horizon) ſo is D A known, in paces, to a fourth number: and the right line F A ſhall befound in paces. Then ſay again, as the whole Sine is to that fourth number, which is the meaſure of A F in paces, ſo is A C the ſecant of the angle F A C, to a fourth number: and thus you ſhall know the number of paces that meaſure the line A C, that is, the length of the Range that that Piece will make upon the plain A E, when you ſhoot upwards.





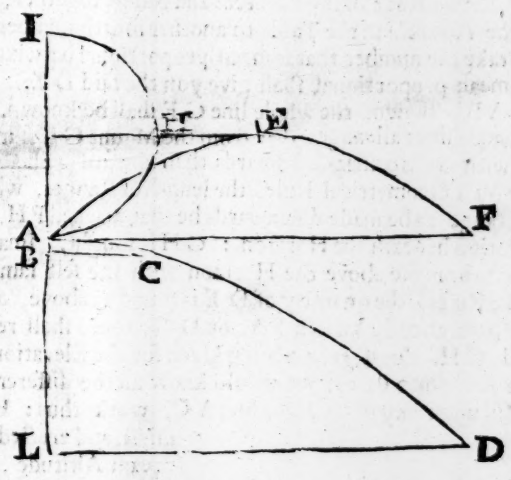
But when from the point A it is required to ſhoot downwards by a deſcending Hill, as A B, we ſhall find the quantity of the Range A B, that is, the place where the Ball falleth, in this manner. Let the direction A E, that is, let the angle of the Pieces Elevation be given; alſo let there be given the angle of the Hills inclination C A B. Let us imagine the Horizon to be A C, and let us draw B E and H D F perpendiculars to the ſame: and conjoyn or draw a line from C to H, which line ſhall be parallel to A E. Now upon the Table of Amplitudes we ſhall find how many paces A D is, but we ſeek the quantity of A B. Therefore make the calculation thus; as F D the Tangent of the angle of the Pieces Elevation is to D H, the Tangent of the inclination of the plain; ſo is A D, known in paces, to a farther number. And this ſhall be the meaſure of D C in paces, and thus the whole line A C ſhall be known in paces. Then ſay again, as A C the whole Sine is to A C known in paces, ſo is A B the Secant of the angle C A B to a fourth number: and this laſt number ſhall be the meaſure ſought of the right line A B in paces; that is, the length of the Range upon the deſcending plain A B. It happeneth alſo many times, that we are to ſhoot at plains perpendicular to the Horizon, as at the Walls of Cities, or Towers, or other wayes; therefore alſo in this caſe we will ſubjoyn the Computation for finding the Altitude of that point in the ſaid Wall where the Ball is to hit.



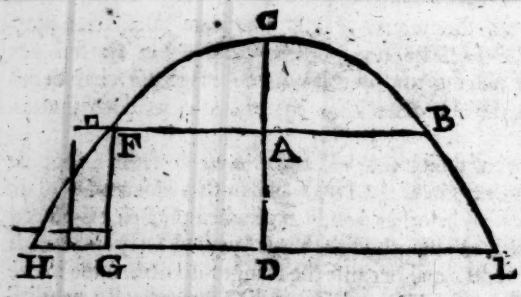
Let the Direction of the Piece be the Line A B, and the Horizon A C, and the Wall of the Tower D E perpendicular to the Horizon: and let the diſtance A D be known in paces. Let us ſuppoſe that the Ball paſſeth freely without hitting the Wall, and falleth upon the Horizon in C. The Table of the Amplitudes giveth the quantity of A C, but we ſeek the Altitude D E. Draw C B perpendicular to the Horizon, and D F parallel to A B, and then draw a line from F to A, which ſhall paſs thorow the common Section of the *Parabola*, and of the Wall, as may be collected from the things already demonſtrated. Now ſay, as C A the length of the Horizontal line is to C D the difference betwixt the lines A C and A D already known, ſo is B C the Tangent of the angle of the Elevation of the Piece, to C F the Tangent of the angle F A C. Again ſay, as the Sine Total is to A D known in paces, ſo is the laſt found Tangent of the angle F A C to a fourth number: which ſhall be the deſired meaſure of the right line D E in paces. And thus we have

have found the point E in which the ſaid ſhot would ſtick. The ſame calculation may be alſo deduced. Although the Wall D E be not perpendicular, but ſcarfed, as thoſe of the modern Fortreſſes; but fearing to procure you more trouble than benefit, I will refer the care of that to the Geometrician that hath a mind to undertake it.

The Amplitudes of the *Parabola*'s, of which *Galileo*, and alſo we do treat, ſuppoſe that the Range terminates not upon the plain of the Field, but in that Horizontal plain that paſſeth by the Muzzle of the Piece. The other is only true when the Peice is placed with its Carriages in a Trench, ſo that the mouth of the Piece lyeth exactly level with the ground. But becauſe this is not uſual, and becauſe the Ranges do determine in the Horizon that toucheth the lower parts of the Wheels, we will Geometrically enquire how much a level Range, or Horizontal Range may be prolonged by means of the Altitude of the Muzzle of the Piece above the plain of the Field. It ſeemeth that the Semidiameter of the wheels, and the thickneſs of the Metal do cauſe the Muzzles of ordinary Artillery to be above the Horizontal Site about two Braces. I ſuppoſe therefore the Muzzle of the Culvering to be at A, and let the Horizon be B C; and let the Altitude of the Muzzle be the right line A B, ſuppoſed to be two Braces; and let the Range A C D be the level Range. The right line B C is ſought; let the Semirect Range, or the beſt of the Randon of the ſame Piece, be the *Parabola* A E F; and let it be ſuppoſed that A F be 5000 Geometrical paces, that is a 15000 Florentine Braces. Deſcribe the uſual Semi-circle of the firſt Propoſition A H I, and having drawn A L equal to A I apply L D. The right line A I, by the things demonſtrated, ſhall be the *Impetus* of the *Parabola* A E F, or of A C D (for they are Ranges of the ſame Piece) therefore A L ſhall be the fourth part of the right ſide of the *Parabola* A C D: therefore L D ſhall be double of L A: but A F hath been demonſtrated to be alſo double of A I; therefore L D and A F are equal; and there are three lines given, that is, L A 7500. L D 15000. and A B 2. And therefore, working by the Rule of three, as the right line L A is to A B known; ſo is the ſquare of the right line L D to another number: we ſhall find 60000; which ſhall be the ſquare of the right line B C; and extracting the Square root thereof, we ſhall find the line B C to be 245 Braces. We conclude therefore that that Machine which maketh its greateſt Range of 15000 Braces, in caſe it ſhall have its Muzzle raiſed above the Horizon, will make its level Range, that is, without any Elevation or Mounture, to be in all 245 Braces long. Next, how much every other Range not level, but inclined upwards or downwards, by occaſion of the Altitude of the wheels, or of a Baſtion, or of a Mount, or of any other ſcituation that raiſeth it above the Horizontal plain, may be prolonged, ſhall be found thus.



It is certain, that being to ſhoot from the top of a Rock, or of a Caſtle placed in the top of an Hill, or from any whatever high place above the Horizontal Plain of the Field that lyeth below, the Ranges will prove much longer than thoſe noted upon the Table of Amplitudes; and this difference ſhall be ſo much greater, by how much the ſcituation of the Artillery ſhall be higher above that Horizontal plain in which the Balls are to hit, and the Ranges to determine.



Let the height of the Hill or other place be G F, and from the point F, let a line be drawn upon the plain of the Field G E: and let us ſuppoſe the Horizon to be F B: now having made the Range F C B E at an Elevation, the meaſure of G E is ſought.

By the Table of Amplitudes, we find the quantity of A B, and by the Table of Altitude, we find A C, the height of the *Parabola*. And for the working of the Computation, it may be performed ſundry wayes.

Let the number of A B be ſquared, and divide that ſquare by A C, and the *Quotus* ſhall be the right ſide of the *Parabola* F C B: Then multiply that *Quotus* by C D, and the ſquare Root of the Product ſhall give D E.

Or we may work thus:

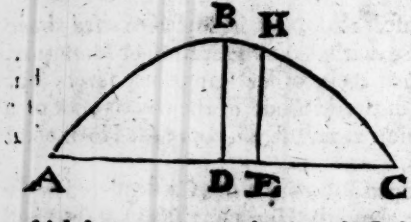
Draw the number D C into C A, and the ſquare Root of the product ſhall be the mean proportional betwixt D C and C A. Then ſay, as C A is to the fore-mentioned Root, ſo is A B to another number. And this fourth number ſhall again be D E.

Or laſtly, in this manner:

Say, as the number C A, the Altitude of the *Parabola* in the Table, is to the number C D, the Altitude of the *Parabola* and Range together, ſo is A B the Semi-Amplitude of the *Parabola* in the Table to another fourth number.

Then take the number that is mean-proportional betwixt that laſt number and A B, for that mean-proportional ſhall give you the ſaid D E. And for as much as D G, equal to A B is known, the whole line G E ſhall be known.

But ſome might alleadge, that from the Mount G F, it may perhaps be required to play with Guns oftner downwards than upwards, therefore it would be neceſſary to know by a Geometrical Rule, the length of Ranges, which is done in this manner. Let the Range to be made downwards be that marked F H, with any whatever angle of inclination beneath the Horizon: G H is ſought. Imagine with your ſelf that the Range is to be made above the Horizon with the ſelf ſame inclination; and by the precedent Rules, the quantity of D E is found as above, or D H, from which if we take the part already known F A, or D G, there ſhall remain known the quantity required G H. But if *gr.* 40 being given for the Elevation of the Range A B C, and the Baſe A C 1600 Paces, we would know all the different Altitudes of the Ranges of the Ball upon any point of the line A C, work thus: Having divided A C in the midſt, and erected D B, this ſhall be the Supream Altitude, and ſhall be found in the Table of Altitudes and Amplitudes working in this manner. In the Table of Amplitudes right againſt *gr.* 40. of Elevation, I find the line A D to be 9848 parts: but in the Table of Altitudes I find the line B D to be 4132 parts. Then, by the Rule of Three, I ſay; if A D 9848 give 800 paces according to the ſuppoſition, how many paces ſhall D B, which is 4132 parts, give? and I find, that the right line B D is 336 paces. Now let any point be propoſed, as E, over which you would know the Altitude of the Range of the Ball, that is the line E H. Let the right line A E be ſuppoſed 1000, and E C 600: and work the Rule of three again, in this manner. If the ſquare of A D, which



which is 640000, give the Rect-angle of the right lines A E and E C, which is 600000, what ſhall the number B D (which was found to be 336) give? and I find 315 paces. Therefore the Altitude of the *Parabola* over the point E, was 315 paces; which is that that was ſought.

It ſhall ſuffice to have hinted this little for the Calculating of ſome varieties that may happen about theſe Ranges. Other caſes may be put, like to theſe, and particularly thoſe of their converſions; but from the knowledge of theſe, thoſe may eaſily be deducted: and the Ingenuity of any Geometrician, applying himſelf thereto, ſhall find leſs difficulty in reſolving many of theſe Problems of himſelf, than in undergoing the length and obſcurity of our explanations. Therefore we will proceed to the making of the *Quadrant*, the which ſeemeth really appropriated, nay, made by Nature on purpoſe for to meaſure Scientifically and Geometrically the Ranges of Projects.

Of the Quadrant.

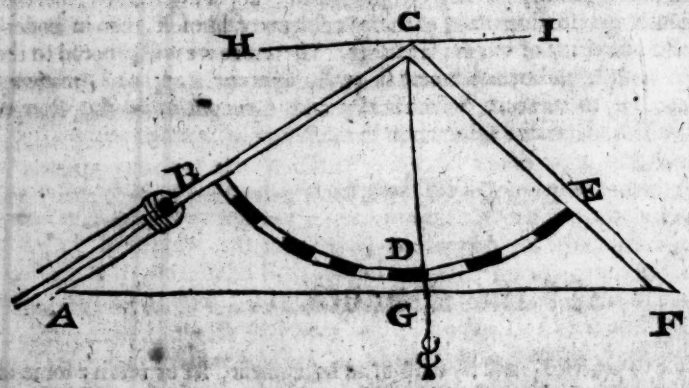
LEt us now come to practice; and by help of an Inſtrument, let us reſolve ſome of the Propoſitions above demonſtrated. We will make a Military *Quadrant*, which with invariable certainty ſheweth (at leaſt to Geometrical Philoſophers, if not to practical Gunners) what Mounture or Elevation ought to be given to any Piece, to the end that the length of the Range may prove to be of ſuch a certain meaſure. We will alſo reſolve, by help hereof, all Problems that can be framed about the ſhooting of Artillery, which were heretofore promiſed by *Tartaglia*, and reduced into Tables by *Galileo*, with ſomething over and above. Military Induſtry did find that the uſe of a Machine ſo noble, and of ſo great conſequence as the Canon, would be too much confined, and of too little benefit, if it could not be made uſe of ſave only at that ſmall diſtance to which it carrieth a point blank, or in its level Range, without giving it with the *Quadrant* the advantageous aſſiſtance of ſome elevation. It was therefore enquired how a man might do that with the ſame Piece, which of it ſelf did not carry more than 200 or 250 Geometrical paces, he might ſhoot 400 and alſo 600 paces, and more and more, until he come to the length of the greateſt Range that can be made by that Piece. The Invention was thus: They began to help the Piece by Elevation, that is, they directed it not ſtraight upon th' object which it was to hit, but, holding it in the very vertical of th' object, they elevated it above that right line which goeth from the Piece unto the object: and this they did ſometimes more, and ſometimes leſs, according as the force of the Shot was to be greater or leſſer: An Artifice that from the very beginning of the world hath been known even to artleſs Boyes. We ſee that when they with a Ball of Snow, or other matter, do aim to hit a mark that is very near, they throw it directly at the mark: but being at another time to aim at one which ſtandeth farther off, or being to throw Stones at each other, they do not throw Horizontally, or directly at their Adverſaries, but turning the caſt half way into the Air, without having ever had any other conſideration, they do all throw at the elevation of the fifth, and alſo of the ſixth point of the Military Square to them unknown: But Gunners, in proceſs of time, have found an Inſtrument, that doth with facility meaſure theſe Elevations.

Nicolo Tartaglia of *Breſcia*, a famous Mathematician, did invent a Square with unequal ſides joyned together with the *Quadrant*, which hath for more than a hundred years paſt, been generally uſed, and is ſtill the only Regulator of Gunners, not only to manage great Guns, and to raiſe them to thoſe Mountures which they call Randons, but alſo to level them in the Point-blank Ranges; *Tartaglia* divided that Quadrant into 12 equal parts, beginning the Numeration of them from the leſſer [or ſhorter] ſide; he alſo ſubdivided each of thoſe into other 12 equal parts, naming thoſe firſt

Points, and these second Minutes of the *Quadrant*. We will insert the figure of the Quadrant, and shew how it measureth the Elevation [Mounture or Randon] of the Piece.

Her Concave, Cilinder, or Bore.

Let the Canons * Soul be A B, fixed at some certain Mounture: put into the Muzzle thereof the greater of the *Quadrant* C A: so that it be applyed to the lower side of the said Soul, and let the Plummet fall in D. I say that the Angle E C D, that is the arch E D, is the measure of the Elevation of the Piece. Draw an Horizontal line A F, the angles at the point G shall be right: But the angle A C F is also right. Therefore the angles C A F, and F C G are equal by the 8



of the sixth of *Euclid*. Or thus; Draw thorough C the Horizontal line. If H I now from the right angles H C D and A C E there be taken the common part A C D, there shall remain th' Angle E C D of the *Quadrant*, equal to the angle of the Piece under the Horizon H I, or above the Horizon A F, which is the same as being alterne.

By the help of this *Quadrant* Gunners have with long observations composed such a *Praxis*, as that they know how many points they are to mount *v. gr.* a Culvering of 40 pound Ball to hit a mark distant; for example, 700 Geometrical paces, or at any other distance.

But the truth is, the observations are fallible, and the Gunners so few that have made them, and made them exactly, that the use of Artillery, taking from it the Range of Point Blank, must needs have very little of certainty in it.

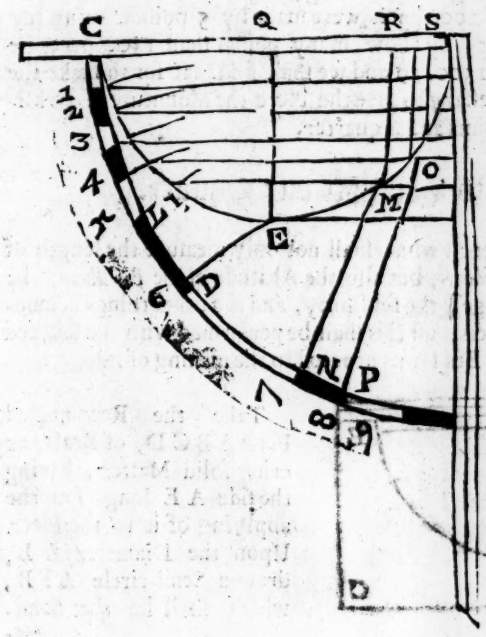
If one would collect some certain Science touching th' ordinary Quadrant, it would be necessary to make the Experiments not only with all sorts of Balls, and with all the varieties of Powder, but in all kind of Pieces, as also in all those that being the same *in specie*, are of different grandeur; and lastly, at all possible degrees of Elevation. A Multiplication that almost runs up into infinity. And we observe that these Experiments ought to be all made one by one; for it is not true, that by way of proportion one may from three or four Ranges of a Canon made at several elevations, argue to any others, no not of the same Canon, laden with the same Powder and Ball. That this is so, may be demonstrated by help of the Tables made by *Signiore Galileo*, and by us. For example, That Canon which being elevated at the sixth Point, curryeth its shot 4000 paces, elevated at one Point, ought to curry the sixth part, at two points the third, and at three points the half of that Range. But the thing falls out far otherwise: For being elevated to one point, it curryeth 1032 instead of 666, which is the sixth part of that same greatest Range 4000: at the second point (and note that with this Mounture, Pieces carry alwayes the half of the greatest Range) in our case will curry 2000 in stead of 1333, which is the third part: At the third point it will curry 2824, instead of 2000, which is the half of the greatest Range: at the fourth point it will curry 3464 instead of 2666: At the fifth point it will curry 3860, in stead of 2333, which are 5 sixths of that greatest Range: See therefore how that increasing equally the Mountures of the Piece, that is shooting first at one point only, then at two, three, four, *&c.* unto the sixth, the increases of the lengths of the Ranges do not increase equally, that is with the same proportion wherewith the

* Randons

* Randons increaſe. But the firſt point currying 1032, the ſecond increaſeth above it 968, the third increaſeth 824, the fourth 640, the fifth 396, the ſixth 140. Therefore to derive ſome rule from the Experiments, it were neceſſary to make them exactly, at all the Grades of Randons, in all ſorts of Pieces, with all varieties of Powders, and different matters of Balls; and happily one might ſay, it were neceſſary alſo that every Gunner made them by himſelf. Things almoſt impoſſible to reduce unto Rules, from which any certainty might be gathered, if the Theorick and Geometry had not given us a manifeſt Science thereof, by means of that one ſole Propoſition of *Galileo*, in which firſt of all men he hath advertiſed and taught us, *That Projects do all move in a Parabolical Line*. Upon this ſuppoſition we will ground the Inſtrument promiſed: and though by the impediment of the *medium* the *Parabola's* become too deformed, or by many other accidents the Ranges prove very inconſtant, yet it ſufficeth us to have given indubitable ſatisfaction to the School of Mathematicians, if not to that of Gunners. *Or Mountures.*

Before we ſet down the making of our ſquare, which conſiſteth only in deſcribing one ſingle Semi-circle, we will divide the ordinary Quadrant into unequal points, ſo as they may not meaſure the Randons of the Piece, but the lengths of the Ranges, which is that that ſerves to our purpoſe. Thus we ſhall be aſſured, that the Gun, if it ſhall be elevated to one point of the ſaid Quadrant, ſhall carry to ſuch a diſtance, whatever it be: and elevated to two points, ſhall preciſely double that Range: and if to three, it ſhall carry three of thoſe ſpaces; if to four and a half, it ſhall carry four and a half; if to five and a quarter, it ſhall carry five and a quarter; and thus until you come to the ſixth point, ſhall the points of the Quadrant in the Inſtrument, and the ſpaces of the Ranges in the Field, alwayes increaſe in the ſame manner, and with the ſame proportion, and from the ſixth to the twelfth point, they ſhall go in the ſame manner decreaſing. The conſtruction and demonſtration is Geometrically taken from the propoſition which we have made the Firſt of this our Book of Projects, which by the Amplitude given, teacheth us to find the Elevation. And it ſerveth in common for whatſoever ſort of Artillery and Mortar Pieces, and for any ſort of Ball or Powder.

Let the ſides of the Quadrant be A B the greater and A C the leſſer; then making A the Center, deſcribe the Quadrant C D E, upon which the unequal points are to be marked or ſet off: and about the Diameter A C draw the Semi-circle A F C; and having drawn F G perpendicular to A B, and Tangent to the Semi-circle, divide A G into ſix equal parts to find the ſix points of the Quadrant, and then again, each part into 12 to find the Minutes, (if the ſize of the Inſtrument ſhall admit of this ſecond diviſion) now let one of the ſix parts be G H. Draw H M I parallel to G F, cutting the Semi-diameter in the points M and I, and then from the Center A, draw the right line A F D, and D ſhall be the ſixth point of the ſquare: draw A I L, and L ſhall be the fifth point of the ſquare: draw A M N, and N ſhall be the ſeventh point; and ſo of all the reſt. Note, that the diviſion will be the more exact, if after you have found the 1, 2, 3, *&c.* points, you do by the Tranſportation or ſetting of them off, deſign the ninth, tenth, and eleventh.



The half points, quarter points, and Minutes, are found in the ſame manner by ſubdividing each of the portions of the line A G into two, into four, or into twelve parts, which raiſing perpendiculars from the points of the Diviſions: Thoſe perpendiculars ſhall cut the Semi-circle, and by the points of the Sections ſhall the Diameters be drawn in the *Quadrant*, and theſe ſhall cut the *Quadrant* in the parts deſired, of Half points, *Quarter* points, or Minutes.

Of Mounture.

Now it is manifeſt by our I. Propoſition, that if the line of the * direction, or of the elevation of the Piece ſhall be A O, or A P, the Amplitude or length of the Range ſhall be as the *Quadruple* of the S O; and if the direction ſhall be A M, or A N, the Range ſhall be as the Quadruple of R M: and if the elevation were according to the line A F D, the Range ſhall be as the *Quadruple* of Q F: but the lines S O, R M, and Q F, by our conſtruction do equally exceed: And, therefore, likewiſe their *Quadruples*, or the Ranges aforeſaid, ſhall equally exceed one the other.

The uſe of the aforementioned Diviſion made in the ordinary Quadrant.

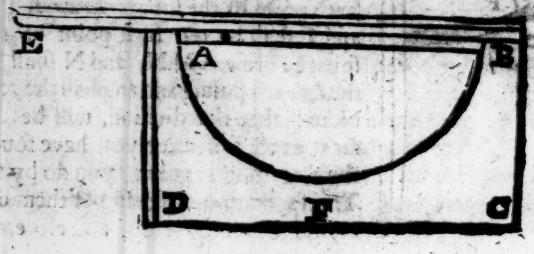
LEt there be propounded any Piece of Artillery, or Mortar-Piece; and with it let there be one ſingle Experiment made, that is, let it be elevated to any point, as for example to the fifth. Let it off, and meaſure the length of the Range, and let it be found, *verbi gratia*, to be 2000 parts; this done we may know how far the ſame Piece will carry, being charged in the ſame manner, and elevated to any what-ever other Point or Minute: which ſhall be eaſie by the Rule of three, the points in this Inſtrument, as well as the length of the Ranges, being proportional. The *Praxis* is this; I deſire to know how far the ſixth point carrieth, I thus ſay, If five points give 2000 paces, how much ſhall ſix points give? and I find 2400 paces. I ſay then that the ſhot of that Piece at the ſixth point, that is at the greateſt Range, will curry 2400 of thoſe parts, at which of the fifth point it curried 2000.

And take notice by the way, that inſtead of performing this operation with the points 7, 8, 9, 10, 11, and 12, It may be done with their Complements, which are 5, 4, 3, 2, 1, and 0.

But if it were required (which importeth much more) that we ſhould elevate the aforeſaid Piece in ſuch ſort, that the length of the Range ought to be; for example, 1300 paces, we are to work thus. If 2000 paces were made by 5 points, or to ſay better, by 60 Minutes of the Quadrant, by how many points ſhall 1300 paces be made? the working will be 2000. 60. 1300. 39, and we ſhall find that for to make the Range of 1300 paces, it would be neceſſary to give the Piece the Mounture of 39 Minutes of the Quadrant, or of three points and a quarter.

The manner how to Compoſe our Square.

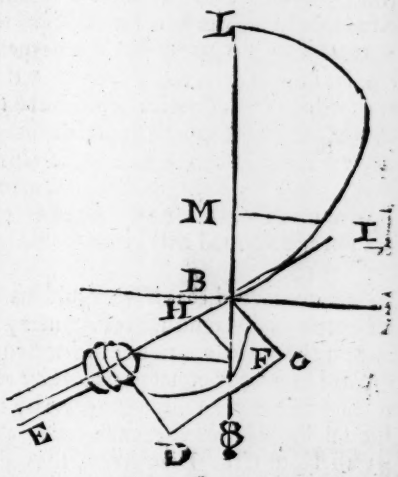
BUt if we would frame an Inſtrument, which ſhall not only meaſure the length of the Ranges made at ſeveral Randons, but alſo the Altitude of the *Parabola*, the duration or time of the flight [or Range] the ſublimity, and the other things demonſtrated in the aforeſaid Book of Projects, all this ſhall be performed with the ſole and ſimple Semi-circle of I. Propoſition. But let us proceed to the making of it.



Take the Rect-angled Plate A B C D, of Braſs, or other ſolid Matter, having the ſide A E long, for the applying of it to the Piece. Upon the Diameter A B, draw a Semi-circle A F B, which ſhall be the Semi-circle

circle of Propoſit. I. *De Projectis* ; and in B place the Thred and Plummet, and divide the Semi-circle A F B into 90 equal parts, which ſhall be the 90 degrees of the Quadrant ; or into 144 equal parts, which ſhall be the equal Points and Minutes of the ordinary Quadrant. Let us now demonſtrate Geometrically, that this ſquare is convenient to meaſure, with exceeding plainneſs, the lengths and the Altitudes of the Ranges, the times of their Durations, the ſublimities of the *Parabola's*, and the Elevations of the Pieces. And then we will ſet down the Diviſion of the Lines thereupon, without the need of any Table for the uſing of the ſame.

Let us, as in the ſubſequent Figure, place the ſquare afore-named E A B C D in the mouth of any Piece, E A at pleaſure, and let the Plummet fall upon the point F of the Semi-circle A F B, divided into 90 equal parts. It is certain, in the firſt place, that the Arch B F meaſureth the Elevation of the Piece E A above the Horizon. For we having by the Diviſion of the Semi-circle into 90 parts only, valued every two degrees for one ; we have made the Arch B F to be the meaſure of the Angle B A F, that is, of the Elevation of the Piece above the Horizon ; which Horizon ſhall ever be the line A F. I ſay moreover, that if we ſhould ſuppoſe the line A B, Diameter of the Semi-circle, to be the *Impetus* of the aſſigned Piece, or the half of the greateſt Range, the line F H, perpendicular to the Diameter, ſhall be the fourth part of the Amplitude or length of the Range ; B H ſhall be the ſupream Altitude of the *Parabola* : A H ſhall be the ſublimity ; and B F ſhall be the time of the Ranges Duration.



That this is ſo, ſhall thus be demonſtrated (having reference to the I. Propoſition of Projects, and its Corollaries.) Let the line of the direction A B I be prolonged indefinitely, as alſo the perpendicular F B L ; then by imagination take B L of ſuch a length, that it may be really equal to half the greateſt Range of our preſent Piece. And about the Diameter B L, let there be imaginarily drawn the great Semi-circle B I L ; cutting the Circumference B I in any point I ; and draw the Horizontal line I M. It is manifeſt, by the afore-cited Propoſ. I. of Projects, that the line M I ſhall be the real fourth part of the length of the Range ; as alſo, that D M ſhall be the (not imiginary, but) real Altitude of the ſaid Range ; and ſo the other meaſures in the Semi-circle B I L, ſhall be all true and real. Now obſerve, that the Triangle H B F is like to the Triangle B I M, as being right-angled, and having two angles at the Point B. Therefore the ſame Propoſition ſhall be between all the ſmall and imaginary meaſures of the ſquare A C, as is between all the true meaſures in the imaginary and great Semi-circle B I L ; that is, the lines, A B, B F, F H and H B, ſhall be to one another in the ſame proportion reſpectively as L B, B I, I M, and M B. Therefore, as to arguing in the proportions, we may without any error, as well make uſe of thoſe feigned proportions upon the ſquare, as of the true ones, imagined in the Amplitude of the Air.

It remains now that we ſhew how this Doctrine, which hath hitherto been a meer Speculation, may now be reduced to Manual practice, and that with facility. Every one ſeeth that for our obtaining knowledge of the quantity of the lines A B, B F, F H, and H B, and their proportions in the precedent Figure, it would be neceſſary that all the aforeſaid lines were divided into moſt Minute parts with ſome common meaſure. To this purpoſe, therefore, we will divide the Diameter A B, and Semi-Diameter E D, into equal and very ſmall parts, as appeareth in the following Figure ; (upon which let us deſcribe the imaginary ſquare) and then let us give to each diviſion of

the circumference, its guides parallel to thoſe Diameters, that ſo in them the number and quantity of the lines which ſhall be Indices of the length and Altitudes of the Ranges, may be read or found: And in the point of the angle of Semi-circle B, place the Thread and Plummet.

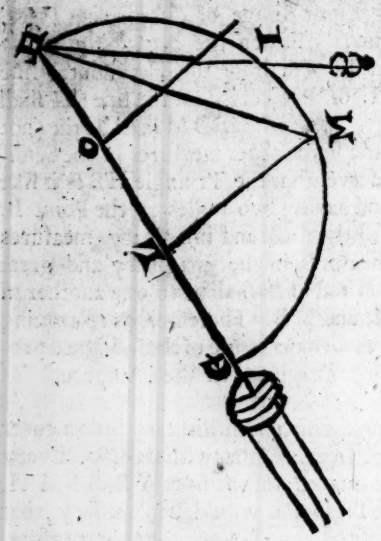
As to the number of parts into which the Diameter A B is to be divided, it ſhall be left to the choice of every one; but yet it will be convenient to make choice of the number 2000, for that it will facilitate the Arithmetical operation.

It is to be noted, that if any one will make a ſquare, as hath been ſaid, on purpoſe for one kind of Artillery onely, he ſhall without the leaſt trouble of Calculation, have the meaſures of all its Ranges.

The Diviſion of this ſquare is to be made *a poſteriori*, in this manner. Make an Experiment of the greateſt Range of that ſame Piece to which you would have the ſquare to be adapted, and let it be found *v. gr.* to be 3000. Then divide the Diameter of the ſquare into 1500 parts, and the perpendicular Semi-diameter into 750 equal parts; that is, imagine that the Diameter A B 1500, is the half of the greateſt Range 3000; as alſo, that the perpendicular Semi-diameter E D 750, is the fourth part of that greateſt Range. And thus, every of the other Elevations being afterwards given, as ſoon as we ſhall apply this Square to the Muzzle of the Piece, we ſhall immediately ſee how many paces is the length, and how many the Altitude of the Range, *&c.* And this ſquare made *v. gr.* for a Canon of 60 pound Ball, would be alſo good for every other Canon of 60 pound Ball, that ſhould be the ſame in length, and other proportions, with that.

It's true indeed, that if we would make the ſquare univerſal, to ſerve indifferently for all Species and Magnitudes of Artillery, we muſt then do thus. Divide the Diameter A B in the precedent figure in 2000 equal parts: alſo let the Semi-Diameter E D be divided into 1000 equal parts, (we by reaſon of the ſmallneſs of the figure have divided it only into 100, taking the parts by ten and ten.) This done, let there be drawn by the Diviſions of the Circumference, cut into equal degrees, as is uſual, the guides parallel unto the Diameters, that ſo one may upon thoſe Diameters read or find the quantity of the right lines, as they ſhall happen to be.

Now let a Piece of Ordnance F G, unknown, be given. Then make the previous Experiment in this manner. Apply the ſquare to the Muzzle of it, and let the thread fall in any place, as in I. Then find by the means of its guide, the quantity of I O upon the divided Semi-Diameter, and keep it in mind, and then ſhoot off the Gun, and meaſure the Range, which ſuppoſe to be, for Example, 1250 paces: charge the Piece again in the ſame manner, and give it a different Mounture, ſo that the thread may fall elſewhere, as in M: the length of this Range is ſought. Say thus: If the number of I O give the length 1250 paces, how many paces ſhall the number of M L, that is found upon the divided Semi-diameter give? and you ſhall in like manner find the length of that Range numbred in paces.

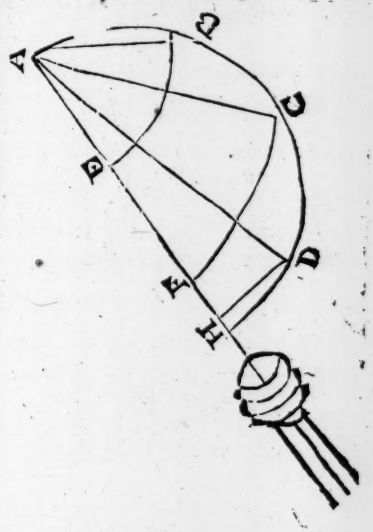


If you deſire the Altitudes, and not the lengths of Ranges, then make the ſame working as before, but not with the lines I O and M L, which give the lengths, but with H O and H L, which give the Altitudes. And if we would have the ſublimities, it would be neceſſary to work with G O and G L. But, which more importeth, if any one after the previous Experiment hath been made, ſhall deſire that the ſame Piece may make an aſſigned Range, in length, *v. gr.* 2200 paces,

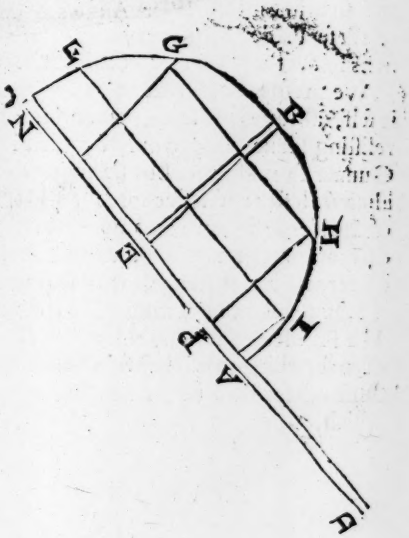
we

we are to find what elevation ought to be given to the Piece. Work thus: If the 1250 paces of the previous Experiment give I O numbred, what ſhall the 2200 paces give? and you ſhall find a number, which ſuppoſe for example, to be aſcribed on the ſquare unto the line M L. the Peice Therefore is to be raiſed to ſuch a Randon, that the thread may paſs thorow the point M; and then the Range ſhall be 2200 paces.

The times or durations of the Ranges are given by the Lines H I and H M: and to find the *Quantity* of theſe it may be done two wayes. Firſt, by way of calculation: For the ſquare of the time H I (in the precedent Figure) is alwayes equal to the two ſquares of the Altitude H O, and of the fourth part of the length I O. Secondly, by making to all the Diviſions of the Perifry B, C, D, (in the preſent Figure) from the Center A the circular guides B E, C F, D H: for A H being thus divided into very ſmall equal parts, it ſhall meaſure all the right lines, A B, A C, and A D, which are the times of the Ranges.



Yet we confeſs as to Military uſe, the Amplitudes or lengths of Ranges, only ſeem to Import; and they are of great moment: the reſt are all acceſſary curioſities, which ſerve much more to the pleaſures of Geometry, than to the occaſions of War; therefore he that would have the ſquare made only for this reſpect of Longitudes, may take the Semicircle A B C of Braſs (as in the preſent Figure) having its ſide A D, and with the Semicircle E B, divided into moſt minute and equal parts, beginning the numeration from the point E; and may give moreover to all the points of the Perifry F, G, H, I, their guides G H, and F I parallel to A C: And thus he hath divided and numbred upon E B all the lines F N, and G O, which ſerve for the Amplitudes or Longitudes of the Ranges.



A Table which sheweth how many Degrees and Minutes of the Ordinary Quadrant inserted Page 20. each Point of one Square, the Points of which are unequal, doth contain.

Points unequal of the square	Degrees of the ordinary Quadrant		Points unequal of the square	Degrees of the ordinary Quadrant	
half	02	23	half	56	46
I	04	48	VII	61	47
half	07	15	half	65	42
II	09	44	VIII	69	26
half	12	19	half	72	10
III	15	00	IX	75	00
half	17	50	half	77	41
IV	20	54	X	80	16
half	24	18	half	82	45
V	28	13	XI	85	12
half	33	14	half	87	37
VI	45	00	XII	90	00

For Example, It is demanded where the Division of the one seventh unequal point doth fall. Look upon the present Table, right against the number VII, and you find that it falleth upon *gr.* 61. and *min.* 47. of the ordinary Quadrant.

Lastly since we are fallen upon the consideration of the Motion and *Impetus* of Projects, we cannot balk th' occasion of adding something concerning the variety of their Forces in battering upon resisting Superficies, sometimes with greater, and sometimes with lesser Angles of Inclination. *Galilæo* considereth th' *Impetus* of these Projects in every Point of their Parabola, and measureth how much it is in its self, that is, in respect of that Plane in which it doth perpendicularly hit.

We presupposing that an *Impetus*, when it is upon the act of striking, is, as to it self, alwayes the same, will consider and measure how much it is in respect of the resisting Plane, varyed only by the diversity of th' Angles of Incidence. There is no Gunner so unskilful, but he knoweth that Cannon Bullets in hitting a Wall, have alwayes lesser and lesser force (if all things else be alike) by how much the Angle of Incidence is more and more acute. So that if the said Cannon with sixty pounds of Iron, and forty of Powder, not only pierceth, but beateth down a Courtin, with its perpendicular Range, it shall scarce hurt it (though it have the same Charge, and *Di ſtriſcio.* the same distance) with the Projection of the Range, which they call * Grazing. The Probleme, for any thing that I know, is unhandled. Therefore if we shall produce something that is less subsistent, and not purely Geometrical, either admit it till some others shall better handle the Doctrine, or wholly reject it, it matters not which.

SUP-

SUPPOSITIONS.

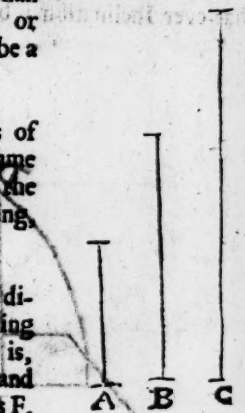
1. WE will ſpeak only of the Ranges of Great Guns; therefore, Let us ſuppoſe, that that portion of the Line which the Ball maketh a little before, and a little after its blow, be as it were a Right Line. I know that we treat of a Line really curved; but being (if it were entire) in length more than three thouſand Geometrical paces, we may take a yard, or a foot, or an inch thereof, without any ſenſible error, to be a Right Line.

2. Let us ſuppoſe ſecondly, that the Forces or *Impetus*'s of Projects are as the Spaces which they paſs or curry in the ſame Time; that is, If the Spaces A, B and C ſhall be paſt by the Moveable in the ſame Time; the *Impetus*'s or Forces in ſtriking, ſhall be as the Spaces A, B and C reſpectively.

Galil. 2. de Motu æquabili.

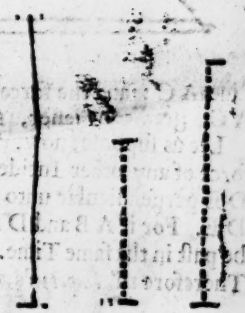
3. But if the ſame Space ſhall be paſt by the Moveable in divers Times, the *Impetus*'s or Forces of the Moveable in battering ſhall have the Proportion reciprocal of their Times. That is, If the ſame Space D ſhall be paſt one while in the Time E, and another while in the Time F; the Force of the firſt ſhall be as F, and of the ſecond as E.

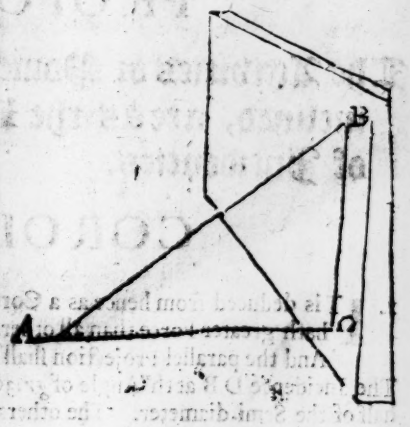
Galil. 3. de Motu æquabili.



4. Let us ſuppoſe, in the next place, that all the Ranges have, as to themſelves, the ſame *Impetus*: which will happen if the Piece being fixed alwayes in the ſame place with the ſame Charge, the ſame Mounture, and Diſtance, *&c.* the obliquity of the Wall be only varied.

This ſuppoſed; when a Cannon Bullet approacheth to the oppoſed Wall, the Line and Direction of the Range is either perpendicular to the Wall, or not. If it be perpendicular, the Percuſſion operateth with ſuch a certain force: which we will prove to be the greateſt that that Range can have. If it ſhall be at Oblique Angles, as the Line A B unto the Wall B C, I do note that in reſpect to the Wall BC, there are in the Line of the Project A B, two Motions compounded together: that is, one of approximation perpendicular to the Wall, the other of paſſage lateral, or parallel to the ſame. The perpendicular Motion is both repreſented and meaſured by the Line A C; the parallel Motion by the Line C B: for both the Spaces A C and C B are paſſed by the Ball at the ſelf ſame Time.

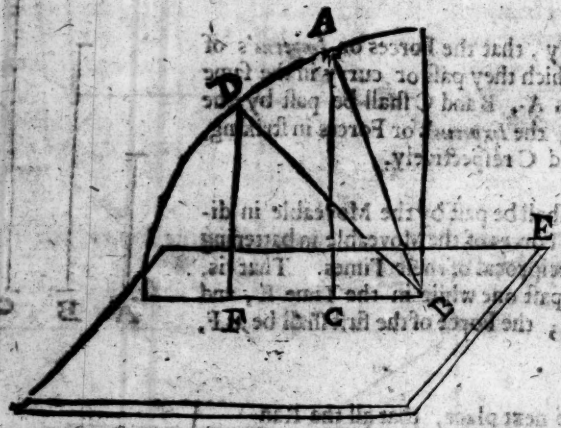




Now obſerve, that of theſe two ſorts of *Impetus*, one onely is to the purpoſe, for encreaſing the Forces to make a breach in the Wall, and to drive the Ball into it; to wit, the *Impetus* of the perpendicular Lation A C. The other, although it were infinite, will never encreaſe the force of the Project againſt the Reſiſtance of the Wall,

unless the perpendicular Lation be withall accelerated. Nay, if the Horizontal Motion were simple and alone, without any mixture with the perpendicular Motion, what other would the Ball do but run equi-distant unto the Wall, without ever touching it, so far would it be from breaking it; although it were a very thin Glass? When therefore, the Direction of any Projection being given, we shall know how much of this perpendicular *Impetus* entereth into the Composition of the Motion, we shall also know the Activity or Moment of the Project towards the Resistance of the opposite Wall.

Let the Line of any Incidence at pleasure be A B upon the Plane B F taken with any what-ever Inclination; but withall, let the portion A B be so small, that it may be taken for Right. Draw A C perpendicular to the Plane, and conjoyn C B. So much, therefore, of Parallel Motion shall be in the Line A B, in respect of the Wall B F, as is the Line C B. But of this we make no accompt; for being multiplyed, it doth not help, and diminished it doth not weaken the Moment, if the other *Impetus* do remain unaltered and the same. Of Perpendicular Motion in the same there shall be as much as the Line A C: and the force of the percussion shall be greater and lesser, according as A C, greater or lesser, shall be past in the same Time.



Let us suppose, now, that the force of th' Evidence A B be as A C. To know the force of any other Incidence D B, let D D be taken equal to B A, and having drawn D E perpendicular unto the Plane, the force of this Incidence shall be as that same Line D E. For if A B and D B are equal, and are the Ranges of the same Piece, they shall be past in the same Time. Therefore A C and D E, are also past in the same Time: Therefore th' *Impetus*'s, as to the Wall, are as A C to A D. We will therefore infer, that,

By Suppos. 2.

PROPOSITION.

The Activities or Moments of Ranges differently inclined, are as the Right Sines of th' Angles of Incidencies.

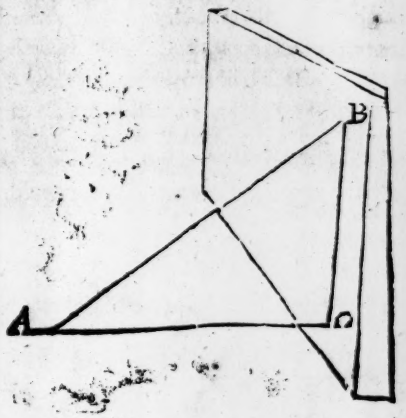
COROLLARIES.

1. IT is deduced from hence as a Corollary, that the Perpendicular Incidence A B, hath greater Force than all others, the force of it being as the Whole Sine. And the parallel Projection shall have no force, its force being as the No-Sine. The Incidence D B at th' Angle of *gr.* 30 hath half of the total force, its Sine being the half of the Semi-diameter. The others, likewise, according as they shall have greater or lesser Right Sine, shall have greater or lesser force.

2. The

2. The Forces of Projections have reciprocally the ſame proportion that the Sides of the Triangle have, which ſhall be formed upon the Plane by the Lines of the Incidencies.

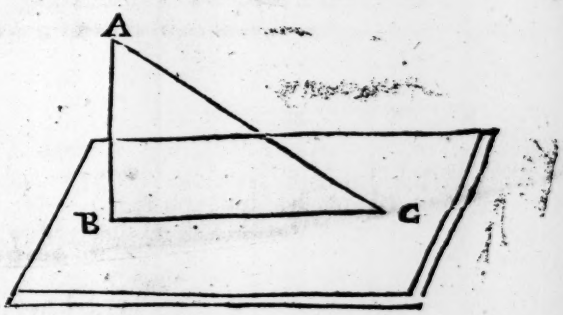
Let a Projection be made along the Line A C, and another along the Line A B. And let the Plane of the Triangle A B C be perpendicular to the Wall. Becauſe now the Space A C is paſt by the Ball in the Time A C; and the Space A B, that is (the parallel Motion deducted) the ſame Space A C, is paſt in the Time A B, the Forces ſhall be reciprocal to the Times: that is, the force along A C ſhall be as A B, and along A B, ſhall be as A C.



By Suppoſit. 3.

3. Projects ſhall then have the ſame force in battering, when the *Impetus*'s ſhall be as the Secants of the Complement of the Incidencies.

Let the *Impetus* along the Perpendicular A B, be as A B; and let it have ſuch a certain force. To th' end that the *Impetus* along the Inclined A C may have the ſame force, I ſay that the *Impetus* along A C, ought to be unto the *Impetus* along A B, as A C is to A B: which A C is Secant of the Angle B A C, Complement of the * Inclination.

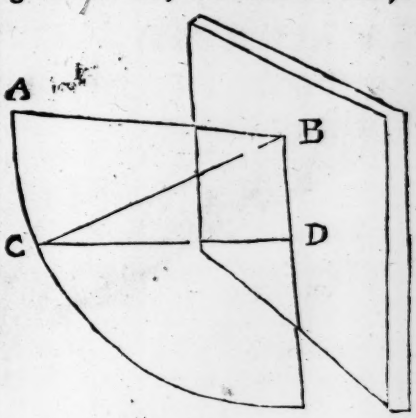


Or rather of the Incidency.

For if the *Impetus*'s along A B and A C ſhall be as the Spaces A B and A C, the Moveables ſhall, in the ſame Time, paſs the two Lines A B and A C, that is, the ſame perpendicular Approximation A B. Therefore they ſhall have the ſame force againſt the Wall.

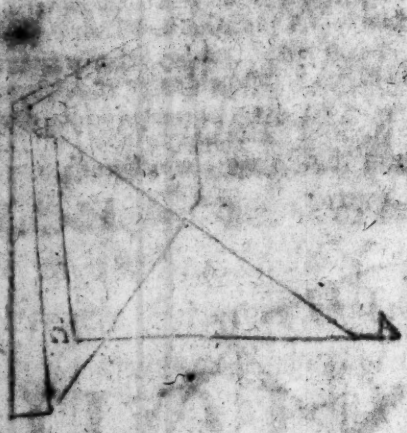
By Suppoſit. 2.

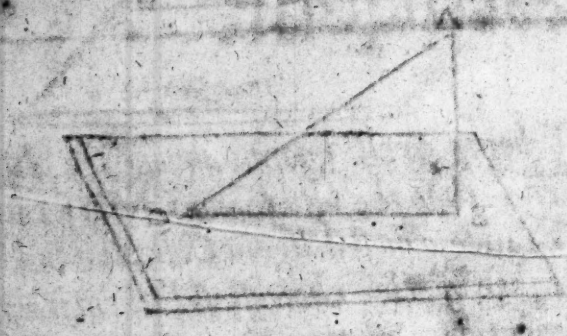
4. Moreover, if with ſuch a Piece, and along the Line C B, the Ball ſhall but juſt enter wholly into the Wall, then along all the more elevated Lines, it ſhall not only wholly immerge into the Solidity, but ſhall ſtill make deeper impreſſion or entrance, becauſe it hath greater force. But becauſe each of the leſs elevated ſhall have leſſer force, none of them ſhall enter wholly into the Wall, nay ſome ſhall rebound and fly back.

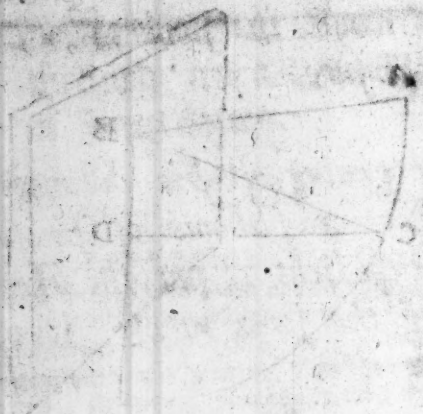


Yet let all this be ſpoken abſtracting from a certain Effect of Pliancy or Refraction that Projects produce in paſſing with Inclination from the Rare *Medium* to the Denſe, the Line incurvating contrary to that of the Refraction of Light, and viſible Species.

FINIS.







TO THE INGENIOUS Student.

IT being well known among the Learned, that the late famous Merſennus of France, a moſt diligent Collector and Publiſher of the choiceſt Mathematical inventions of that time, hath among his Phyſico-mathematical Reflexions, and Mechanicks, divers material Experiments and Theories relating to the Art of Gunnery, it was thought fit for the Readers benefit to cauſe the ſame to be tranſlated, and ſubmitted to his cenſure.

Moreover that Author giving all his diſtances in feet, or paces of three feet, or fathoms of ſix foot; It was thought likewiſe expedient to put the Reader into a capacity of reducing the ſame to our Engliſh

measure, to which purpose there being an accurate experiment made some time since by the most learned and Reverend Doctor John Wallis *Savilian Professor of Geometry at* Oxford, *take an account thereof, as the Doctor communicated the same to a friend of his here, namely, that he hath formerly compared the* French *and* English *foot very exactly, both measures being as he was assured very exact to the Standards of each Nation, and he found the* French *foot to contain of ours* $12\frac{4}{5}$ *Inches (not missing so much as* $\frac{1}{100}$ *part of half an Inch.)*

OF

OF THE

Swiftneſs

OF

SOUND.

The ſwiftneſs of Sound is greater than the ſwiftneſs of Bullets ſhot off, and finiſhes 230 fathoms in the ſpace of one ſecond minute.

WHoſoever would try the ſwiftneſs of Sounds by night, and by day, either in valleys, woods, or mountains, either with or againſt the wind, or when it is rainy or fair weather, ſhall find in all reſpects as I have tried it, that there will be alwayes the ſame ſwiftneſs of Sound.

But after that you have ſearched out a ſecond by 230 fathoms, he that ſhoots off a leſſer Gun, may again retire 230 fathoms, ſo that he may be gone back from you 460 fathoms, the ſame or the like Sound in paſſing over that way will ſpend two ſeconds; which when it ſhall be five times multiplied by us, that we ſhould hear the Sound 1150 fathoms, the flaſh by night breaking forth from the mouth of the Gun is alwayes ſeen at that diſtance before the Sound is heard five ſeconds of time. And ſeeing we make a *French* league to be 2500 fathoms, and the circuit of the Earth 7200 of ſuch leagues, you may eaſily conclude in what time the ſound does paſs over one whole or ſeveral leagues, for the ſwiftneſs of the ſound is not diminiſhed by its debility, whenas the laſt part of the Sound that may be heard does emulate the ſwiftneſs of the firſt.

The Sound of the Gun therefore will paſs over a league in the ſpace of 11 ſeconds, ſeeing a league contains 11 times 230 fathoms (the ſpace paſſed over in a ſecond minute) leſs onely by 30 fathoms, which are here ſcarce worth conſideration, becauſe that they are paſſed over by the Sound in the ſeventh part of a ſecond.

From which many things may be gathered; firſt, that a Souldier attentive may decline or ſhun the ſhot of a Gun at one hundred fathoms, is he foreſaw the flaſh of it; which I thus demonſtrate: It is evident from obſervation, that a Bullet in flying 100 fathoms does at the leaſt ſpend a ſecond of time, and the Sound of it in paſſing of them does at the moſt ſpend but half a ſecond. Therefore the Souldier from the fire ſeen (if Viſion can be in an inſtant) hath a whole ſecond wherein he may eaſily go three or four paces before that the bullet can fly ſo far; alſo there remains to him half a ſecond from that point of time in which he hears the Sound, until the coming of the Bullet: although I would not adviſe any one to try that, unleſs he firſt fortifie himſelf with a ſhield, helmet, and all other kind of Armour, that he may be out of all danger. But any one may try at behind a wall, to which the Sound will come before the Bullet.

Secondly, from the Sound and fire obſerved, may be known how much the Guns are diſtant that are ſhot off againſt the beſieged, or beſiegers, even as to the ingenious Gunners there will not be wanting matter to promote their Art.

Thirdly, by hearing the Sound of Thunder, and ſeeing the lightning go before may be known how far it is off, ſo that if the Thunder be not changed from the place where the lightning was ſeen; for how many ſeconds (whether meaſured by the pulſe, which exactly continues a ſecond, or by a Pendulum or any other Watch) there are between the Lightning and the Sound, ſo many 230 fathoms are to be reckoned; ſo that if you number five ſeconds it may be diſtant from you half a league; if ten ſeconds a whole league, whether the diſtance ſhall be upright, or ſideways and oblique, for it matters nothing.

Fourthly, If by the turnings and windings or Circles in the air a ſound in the ſame manner may be conſidered, and cauſed, as we ſee circles extended in the water ſtruck with the finger or a little ſtone, as all almoſt believe, and if from the ſwiftneſs of bodies in like manner moved we my gheſs at their craſſitude, thickneſs and weight, we may ſay that water is 1380 times thicker and heavier than air; for as much as the Semidiameter of Circles of the Water in any manner ſtruck, which is made in a ſecond of time, ſcarce exceeds a foot, in which time the ſemidiameter of Circles in the air, made alſo by any percuſſion is 1380 foot, that is 230 fathoms; which proportion of gravities come very near to obſervations by him mentioned. There is yet one thing that may cauſe ſome doubt, which is, that the Sound of greater Guns moves more ſlowly than of leſſer, whereas our Geometer in the ſiege at *Theodonis* obſerved that their Sound was heard, from the fire ſeen, after thirteen or fourteen ſeconds of time, when yet he was ſcarce half a league diſtant from thoſe Guns; And the Sound according to that which hath been before ſaid, may paſs over a whole league and more in that time: Wherefore the Sound of thoſe Guns doth ſeem to be different from that of leſſer Guns.

The Author having by this diſcourſe argued that the Sound of Guns is heard at the diſtance of above 16 miles a minute (which is almoſt as ſwift as the *Copernicans* ſuppoſe the Earth to move in its diurnal revolution about its Axis) it was thought fit to ſubjoyn hereto the Authors latter thoughts of the ſame Argument, publiſhed three years after.

OF

OF THE

SWIFTNESS

OF

SOUND,

And force of Bullets ſhot out of Guns.

WHen I have oftentimes conſidered that the Sound paſſes over 230 fathoms in the time of a 2d or ſixtieth part of a minute; and that there ſeem to ariſe ſomeed doubt, whether there ſhould be that Swiftneſs of the Sound of greater Guns, as there is of leſſer, with which I tried; at length it was obſerved that in the ſpace of eleven ſeconds, the Sound of the greater Guns of the Kings Armory, have paſſed from the ſame Armory, after the flaſh was ſeen, as far as our houſe, or the *Vicennian* Convent, whilſt for obtaining the ſurrender of *Pouploon* the Guns were ſhot off by night.

But when with a fathom I found that it was 3524 fathoms from Port Saint *Anthony* to the gate of the aforeſaid Convent, where the ear was, and to the wall of the *Vicennian* Caſtle firſt meeting it, near 2500 fathoms, 'tis certain firſt that it is a juſt league of 2500 fathoms from the Garden walk of the Armory, from whence the Guns are wont to be ſhot off, to that Caſtle: for if any thing in the paſſage muſt be diminiſhed that diſtance will well enough equal it, whereby the corner of the Garden is more diſtant, or the walk by *Sequana* nearer from the Caſtle, than Port Saint *Anthony*.

It is evident therefore that the Sound runs over more than 230 Fathoms in each ſecond, to wit, 320 in every ſecond, which make 1920 foot; which ſince any one can prove by his own experiments, I need not ſay more thereof.

But ſome may imagine that hence perhaps muſt be concluded that greater Sounds paſs more ſwiftly, which diſagrees with divers obſervations. But when ſometimes theſe experiments ſhall be repeated, that I may number the ſeconds, I ſhall advertiſe, for as much as I conjecture that there is no ſwiftneſs of ſound greater than that, which I have proved of 230 fathoms for a ſecond; for in theſe ſmall matters I do not approve that common ſaying, He that acts by another, ſeems to act by himſelf; who want not opportunites may obſerve for their own ſatisfaction.

But now we ſhall add ſome thing concerning the ſwiftneſs of Bullets ſhot out of Guns. When therefore at the Marqueſſe of *Doraiſons* four leagues from the *Sextian* waters, I commanded a Braſſe Gun nine foot long, whoſe name was the *Marchioneſs*, commonly called *la Marquiſe*, (whoſe Bullet was two pounds and an ounce, but quantity of Powder, ſuch as is wont to be in the uſe of leſſer Guns, the weight of one pound) to be levelled horizontally, with a plum line I found that the Bullet ſhot off Horizonitally, in the time of five ſeconds had paſſed over 630 fathoms or 3780 foot, and had reached the horizon, or fell to the ground, as was evident by the huge quantity of duſt raiſed by the blow.

Moreover that point of Earth which was firſt ſtruck by the Bullet was depreſſed under the horizon of the Gun 27 fathoms, for otherwiſe the Range ſhould not have been ſo great before its fall to the earth, which meets ſo much the more ſlowly by how much it is the more depreſſed under the Horizon of the Gun ſhot off, and I preſume I have attributed a leſſer ſwiftneſs to the Guns than is juſt, unleſs yet

the Bullets of the greater Guns ſhot off with very fine powder, which we uſed, may exceed the ſwiftneſs of Bullets ſhot from Harquebuzes; of which thing I do not yet paſs judgement, till experiment, ſhall bring ſome further evidence: but I ſhall propound ſome things newly obſerved.

Now therefore of the Bullet which I made trial of, I affirm that the ſwiftneſs was ſo great that, at leaſt, in each ſecond minute it could paſs over 126 fathoms.

I ſaid, at leaſt, becauſe the obſervers know that the force on the Bullet doth go before the excuſſion or flaſh of the powder, and the perceiving thereof; ſo that half a ſecond may well be attributed to this time. Moreover in the firſt ſecond the Bullet paſſes more ſwiftly, in which time I doubt not but it paſſes over 150 fathoms; Laſtly, if by reaſon of that tarrying which happens betwen the ſmiting of the Earth until the duſt is ſeen to riſe, we ſhould augment that ſwiftneſs by ſo many fathoms as it could paſs over in half a minute, to wit 70; and that the ſwiftneſs be ſuppoſed almoſt equal for the time of five ſeconds, and in each ſecond of that time that it paſſes over 140 fathoms, that is, if the point of the Earth firſt ſtruck were 700 fathoms diſtant from the Gun, it would reach it in the time of five ſeconds. Then the ſwiftneſs of the Bullet may be determined from what hath been ſaid, to be 130 fathoms, at leaſt, in the time of a ſecond: which alſo agrees with the experiments of Bullets ſhot from leſſer Guns: to wit, they paſs an hundred fathoms in the ſame time as the Sound of the Gun hath the ſame paſſage.

For if, behind a wall that is to be ſtruck by the Bullet, the ear be attentive, in the ſame inſtant the ſound and the percuſſion of the Bullet is heard, as if the very Bullet had cauſed that Sound; which doubtleſs you ſhall find to be true as I did if you try: although it will be worth the labour to prove it, not only with that moſt refined powder, which they are wont to uſe who ſhoot at a mark for a wager, but alſo with the courſer ſort of Powder for great Guns, that it may be obſerved whether it cauſes any ſenſible difference of the ſwiftneſs.

Whatſoever powder you uſe, the leaſt ſwiftneſs of the Bullet, may be defined in the firſt ſecond an hundred, the greateſt 150 fathoms, if you put but ſo much Powder into the Gun as is neceſſary for a good ſhot; for if you put in but a few grains which can ſcarce ſhoot the Bullet off, another thing is to be ſaid.

I add that a Bullet ſhot vertically or Perpendicularly upright from the aforeſaid Gun in its aſcent and deſcent, ſpends 36 ſeconds: which if it ſpend ſo much time in its Riſe as in its fall, and that a heavy body deſcending in the time of 18 ſeconds alwayes keeps the ſame proportion in haſtening its deſcent which it keeps in the four firſt ſeconds, the Vertical aſcent ſhall be 648 fathoms, foraſmuch as a Bullet of ſix pound Weight of that Gun, which the Illuſtrious Knight *Hugenius* cauſed to be ſhot off at the *Hague* upon my requeſt, in its aſcent in the time of 16 ſeconds paſſed over 512 fathoms, which falling, pierced three foot into the Earth.

But two things there are which may leſſen the ſpace of the aſcent; firſt, that perhaps the bullet may not ſpend ſo much time in its aſcent as in its deſcent, becauſe Arrows in aſcending paſs over the ſame way in three ſeconds of time that in deſcending they do in five ſeconds: furthermore ſhould we imagine to ſhoot with the mouth of the Gun towards the Earth, the Bullet would pierce deeper into the Earth, than by its mere fall, as it happens in Arrows: whence there ariſes in me no ſmall ſuſpicion that the eyes in the aſcent of the Bullet are deceived, to wit that the Bullet was even falling when it was yet eſteemed to aſcend: which alſo may be imagined of Arrows, which perhaps had began to deſcend when they ſhould ſeem to be inverted, that the point which went before aſcending ſhould likewiſe deſcending antecede: which you may conclude of from the ſmall blow of the Bullet deſcending, unleſs you may contend that the ſtroke made by the Bullet ſhot upright from the mouth of the Gun and falling upon the Earth very near, is greater indeed than the ſtroke of the ſame Bullet ſhot from the greateſt height, and that not by reaſon of the greater ſwiftneſs, but by reaſon of the air ſo unawares intercepted and oppreſſed, that it may much

better

better turn over or bore through the Earth, than when it is prepared for the laſt motion by the Bullet falling ſlowly.

Which indeed can be known by Rocks and Mountains 600 fathoms high, to wit, one ſtanding on the top ſhall obſerve what time the Bullet that is ſhot off at the foot of the Mountain, ſhall ſpend in coming to the top or any other place of the Mountain, and a ſign being given ſhall warn the leveller of the Gun of the time, or from it ſhall learn the time of the aſcent and deſcent: from which cutting off the time of the aſcent ſhall conclude how much ſhorter it ſhall be in the time of the deſcent; which alſo may be obſerved by an iron Bullet red-hot ſhot off in the night, whilſt it can be ſeen light to the greateſt height: however it is I think fit to add the obſervation of that Holland Gun, which being levelly or horizontally ſhot off, carried a Bullet of ſix pounds 398 paces, before it firſt touched the Earth, taking a pace for three foot; after this Space it made eight leaps, and at length it ceaſed at 1750 paces: we have here expreſſed the diſtance between each leap, as likewiſe the diſtance of each grazing from the Gun.

	Paces.	
The paſſage in the air was	——	398
	392	
The firſt leap--	——	790
	275	
The ſecond leap-	——	1065
	179	
The third leap--	——	1244
	150	
The fourth leap-	——	1394
	81	
The fifth leap--	——	1475
	73	
The ſixth leap--	——	1548
	78	
The ſeventh leap	——	1626
	124	
The eighth leap-	——	1750

Moreover a middle range of 45 degrees was 3225 paces, whoſe half if we take it for an upright or vertical ſhot, will be 3225 foot, or 537½ fathoms, for which before we counted only 512. Hence it comes to paſs that we may judge that a vertical ſhot in the aſcent doth not proceed by the ſame or equal and proportionable degrees of ſwiftneſs, by which it falls in its deſcent, for at leaſt there are wanting 25 fathoms, by which 512 differ from 537, although that way of him that levelled the Gun, in counting by common paces, reſtrained to no rule, cannot be ſo certain, but that the other may differ from it, ſo that it cannot with undoubted certainty be reduced to our defined fathoms.

Whoever therefore would certainly try, let him have a chain or wheel for counting of fathoms or any other determinate meaſures, as is done in the paſſage of the league of 2500 fathoms from the *Baſtilian* Tower erected right over againſt Port Saint *Anthony* as for as the walls of the *Vicennian* Caſtle that firſt meet.

There remaines one thing that may diminiſh the upright height, to wit, that the Bullet ſpends more ſeconds in the deſcent than it ought, after it comes to the point of equality, after which it doth not any more augment its own ſwiftneſs: ſo that not only 16 ſeconds are to be reckoned for the deſcent of the Holland Bullet, but perhaps 20, and 12 are to be counted for the aſcent.

For although in moderate heights of 40 or 50 fathoms, the acceſs to the point of equality, in leaden Bullets may not be ſufficiently obſerved, it does not thence follow that it comes not to ſuch a point, in greater heights of an hundred or more fathoms; yea experience proveth the Contrary.

Let there be taken a Corken Bullet which is at leaſt 70 times lighter than a leaden one, yet both them almoſt in the ſame time make a three foot ſpace, although perhaps the Corke attains its point of equality within 50 foot.

But whether a leaden Bullet 70 times heavier, can paſs over a ſeventy fold ſpace, that is, 3500 foot, before it comes to its point of equality, which little differs from the height to which Bullets arrive that are vertically ſhot out of Guns, although I cannot yet conclude, yet it ſeemes probable enough to me. Moreover the force will never be augmented after the arival at that point, if the greater force ſhall be argued from only the greater ſwiftneſs. But note, it hath been obſerved by a Noble man who related it to me, that a field Gun 18 foot long, and cut ſhorter foot by foot, did alwaies curry its ſhott the further till it came to be eleven foot long, and then it began not to give ſo great a Range.

To which may be added from the experience of ſome in ſmall Guns, that if it be over charged with Powder, part of the Powder will blow out of the Gun without firing. Morever if the Bullet be not quite rammed home it will pierce the further, and the Gun recoyle the more.

Alſo that where the Gun is found moſt to furr with many ſhootings off with Powder, there it ought to be cut off, the remainder being the proper length requiſite.

It hath been related that a ſhip becalmed and tormented with the Cuſhee Piece of a Galley, that lay in a manner out of ſhot, was at the laſt reached by the induſtry of a Mariner, who wrapping up a much leſſer ſized Bullet than the Bore of the Gun made uſe of required, in a good Wad did ſhoot as far as the Galley, thereby retaliating the Injury received.

Of the Depreſſion of ſhot below the Marke.

I Have often took care that a Gun ſhould be ſhot off commonly called an Harquebuz, at the ſpace of an hundred fathoms from the mark, that is, ſix hundred foot, which make three hundred common paces, and found that the Bullet was depreſſed under the mark-line eight or ten foot, which would ſcarce have made a greater ſpace, if it had fallen perpendicularly down at the ſame moment of time it was left off.

Again at the the Marqueſs of *Doraiſons*, a Bullet ſhot off, in the ſpace of five ſeconds of time fell 27 fathoms beneath its horizontal line or marke; and whereas perchance the riſing of the duſt, and the perceiving of it might make us loſe a ſecond of time, and that we retain only four ſeconds, then in each ſecond the Bullet ſhould be carried 157½ fathoms (ſurely not more) yet it ought to have deſcended 32 fathoms, if it deſcends ſo much horizontally ſhot off as it would naturally fall were it not ſhot off, and therefore it either loſes ſome thing of its deſcent by reaſon of its being ſhot off, or in running 360 fathoms, it ſpends not ſo much as four whole ſeconds of time, but rather about 3¾.

We add that ſomething is by this means abated from the ſwiftneſs of the fall for the ſpace of 27 fathoms which the Bullet in ſhooting off did deſcend, or fall below the marke: ſo that all things conſidered, I would not as yet ſtart from that opinion, which holds that two heavy bodies, to wit, two Bullets, whereof one may fall perpendicularly from its place above the Horizon, and the other be forced horizontaly, ſhall both in the ſame moment of time arrive at the ground or Horizon: for example, if the pit of the aforeſaid *Marqueſs* be 27 fathoms deep, as indeed it is, if I rightly remember, or alſo a little deeper, 32. a Bullet ſhot into the fields incloſed between the Sextian waters, will hit the horizon, the ſame moment

Of this there is a controverſie between Borellius *who publiſhed a Treatiſe* de vi percuſſionis, *the which was writ againſt by* Honorato Fabri *in his Dialogues of Motion.*

ment, that the like Bullet falling, ſhall the ſuperiour ſuperfice of the aforeſaid point of the water.

There is another thing that I may ſuſpect, whether or no the ſurveyour hath accurately enough meaſured the horizontal depreſſion; however it be, you ſee with what difficulties experiments are hedged in, and how much natural knowledge is indebted to them, who are enriching the ſame with exact Obſervations.

But note that the air that meets the bullet that is ſhot off does ſo much hinder or diminiſh its motion, as much as a wind of the ſame ſwiftneſs with the Ball, blowing continually againſt the ſame in a vacuum.

For is it not the ſame impediment, or deſtruction of the ſame force, if the bullet beats the aire or is beaten of it? But when I ſaid it was known by experience, that water does ſo much the more deſcend, by how much the ſlower it moves horizontally, and the ſame may ſeem to be concluded of other projected heavie bodies; I advertiſe that obſervations are not yet made ſo exact as that any thing of this nature ſhould be too poſitively aſſerted.

Of the Impediment of the Air.

IN regard that Bullets ſhot from Guns do about the end of their motion utter a more vehement noiſe or hiſſing than about the middle or onwards; there is no doubt to be made but that they move more ſlowly, and the force decreaſing as the ſwiftneſs, *Merſennus* concludes that the Curved range line deſcribed by a Bullets motion cannot exactly deſcribe a Parabola, but however the Theory is tolerable, admiting the firſt violence to move in the touch line of a Parobola, and it is likely the greater Mountures cauſe the greateſt difference, becauſe, there is ſo much the more Air beaten and removed by the paſſage of the ſhot.

But yet it is moſt hard to find out, how much the Air hinders; for although it ſeems to hinder ſo much, as the wind agitating the air with the ſame ſwiftneſs, ſtrikes upon the Bullet ſhot off; yet we are Ignorant of the force of that wind compared with the force of the Bullet ſhot off; unleſs we may appeale to our other experiments in which is ſhewn that the air *is* at leaſt a thouſand times lighter than water: and ſeeing that a leaden Bullet is eleven times heavier than water of the ſame bulke, a leaden Bullet will exceed the weight of the air 11000 times: and therefore the air agitated by the ſame ſwiftneſs of the Bullet, meeting with the bullet, ſeems to take away the 1100 part of the ſwiftneſs from the Bullet ſhot off.

Which impediment truly is ſo light, that in the deſcription of the Parabole it ſcarce ought to be conſidered.

Thoſe things are very excellent which the famous *Torricellius* hath ſet forth in his approved Treatiſe, to which *Merſennus* referrs his Reader.

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Experiments OF SHOOTING.

Wherein is explained various obſervations concerning Guns; And what might happen to bullets ſhot off in a vacuity, diverſe waies compared with thoſe which are obſtructed in the Air.

WHenas I made trial about the ſhooting of Bullets in Guns only of an indifferent bigneſs (which we commonly call Harquebuzes) which in the aſcent and deſcent together ſpend 22, 23 or 24 Seconds of time, *Peter Petil* a man moſt skilful and accurate in obſervations whileſt he lived at *Francopolis*, found (at my requeſt) the Range of a ſhot, out of a great gun, at the elevation of 22 degrees, whoſe iron Bullet weighed 33 pounds and $\frac{1}{2}$, to be 1900 fathoms, which the Bullet flew or paſſed over in the ſpace of 20, 21 or 22 ſeconds; the Gun being placed at 8 fathoms in the Caſtle above ground or Horizon; from which place a Bullet of 12 pounds which ſo many pounds of gun-pouder ſhot off at the elevation of 16 degrees above the horizon, ſpent in the air 16 ſeconds.

Beſides, a Culverine of 12 foot long and horizontally levelled being 6 fathom high above the Horizon of the ocean and ſhot off, the Bullet, whoſe diameter was almoſt five Inches, continued 8 ſeconds of time in the air; when yet another Bullet whoſe diameter was 6 Inches and $\frac{1}{2}$, alſo horizontally ſhot off out of an other Gun 12 foot and $\frac{1}{2}$ long, ſpent only 6 ſeconds in the air; another Gun ſhot off at the Elevation of 15 degrees, its Bullet ſpent 24 ſeconds in the Air.

An Iron Culverine of 10 foot long, whoſe Bullet, had a diameter of almoſt four inches, horizontally levelled, and ſtanding 9 fathoms above the ſurface or brim of the Sea, ſpent only three ſeconds, in its horizontal Range, after which grazing five times above the Ocean, ſpent four other ſeconds.

Three daies alſo before the taking of *Theoud*, *Robervallus* our Geometer obſerved, the Bullets of Guns ſhot off from the City againſt our Souldiers, for the moſt part to ſpend only 14 ſeconds of time in the air, after which there was a hiſſing increaſed more and more until the force and motion of the Bullet was almoſt quite extinguiſhed, and that after the ſhot had flew almoſt half a league.

Which being ſuppoſed it may be Theorically concluded, how great the ſhoots ought to be at whatſoever elevation above the horizon, if they be in ſuch Proportion one to another, as ſhots in a Vacuity, no Medium hindring; that is, for example, if the range of 45 degrees be double the height of the Perpendicular or vertical ſhot in a ſpace not hindring, ſo is the range of 45 in the air to the vertical in the air, and ſo of the reſt; which obſervations only will teach; which yet are moſt difficult in the greater ſort of Guns or Bows, eſpecially the perpendicular, whoſe height we can ſcarce certainly know, unleſs ſome rock might be found high enough, to whoſe top, or ſome certain place, the Bullet or Arrow may come, the height of which top or place we may afterwards meaſure.

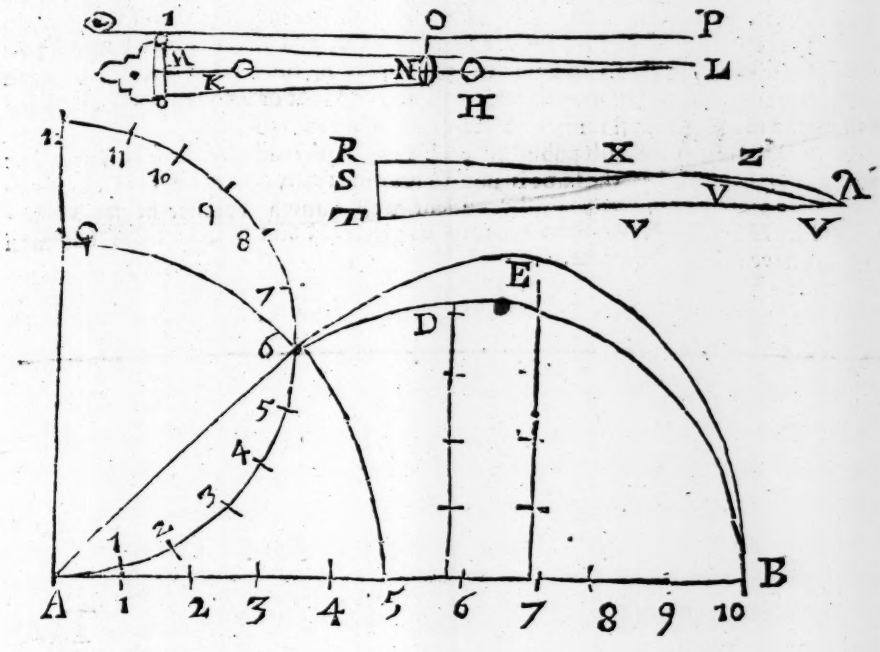
No Towers ſurely are high enough; and by the time of the deſcent or fall of the Bullet, to conclude a place may be found to which bullets, darts, or other things that are caſt upright or vertically aſcending, do come, doth therefore fail, becauſe they do not obſerve the ſame rule of ſwiftneſs in deſcending; as is evident from darts, to which ſeeing it happens in their aſcent or riſe of 50 fathoms to be ſlackned in their deſcent or fall, ſomething like this may be alſo thought to happen to Bullets, to wit, when they deſcend from the height of a thouſand fathoms.

But you may avoid theſe difficulties: for if from that rock in the *Dolphinate*, whoſe height

height 'tis ſaid is 600 fathoms or more, a ſtone or bullet of Iron or any other matter be let fall, * the time of its falling being noted, as for example, if in the ſpace of 18 ſeconds it fall from the height of 648 fathoms (as truly it ſhould fall, if the ſpaces be in Duplicate *ratio*, or as the ſquare of the times in the whole deſcent) then we have rightly judged before of the vertical altitude or perpendicular ſhot (which the Bullet of an indifferent Gun reaches) that is the height of 288 fathoms; which yet I cannot credit; otherwiſe the middle ſhot or range of 45 degrees of that Gun at leaſt would be double to that perpendicular or vertical one, that is to ſay, it would be 576 fathoms, whenas I found it not 400 fathoms.

Experiments of this kind the Reader will doubtleſs find, as alſo others about Pendulums *in the* Opuſcula Poſthuma *of* I. Bap. Batiani.

Beſides theſe obſervations I ſhall add thoſe which the induſtrious *Galeus* an Engineer to divers Dukes in whoſe preſence he made them, writ with his own hand and gave me, which that you may more eaſily underſtand, let the greater Gun K, which we commonly call a Cannon, be parallel to the Horizon, and let the eye be taking aim by the points I and O, the horizontal ſhot being ſuppoſed O P, or in the figure beneath, S X, or, T V, he ſayes that the remainder of the rang which bends till it touches the horizon in the point λ, is almoſt equal to the horizontal ſhot, that is, that there is almoſt as much ſpace made by the bullet from that point, from which it begins to bend towards the horizon, un til it touch it, as it had made before the bending of it.



But now let us ſuppoſe that horizontal ſhot O P, or T V, removed to the lower figure in which let A B be the horizontal plain, and let the the aforſaid horizontal ſhot be A I, *Galeus* contends that the middle range of 45 degrees, which is the longeſt of all, is eleven fold the length of the horizontal ſhot O P, or A I: And in thoſe Guns which are half the weight of the foregoing greater Guns, to be in reſpect of A I, as 10 and ½ is to 1, and in leſſer Guns as 10 to 1 that is our figure, as A B in reſpect of A I; in which the middle range is A G E B; for that is the middle range

which paſſes through the middle of the quadrant ϕ 5, which they call the ſixth point, becauſe it is the middle part of the half circumference A, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, divided into 12 equal parts; which joyned to the quadrant ϕ 5, may be uſeful for levelling the gun at any elevation above the horizon, if it ſhall be divided not only into 12 parts, but alſo into an 180 degrees.

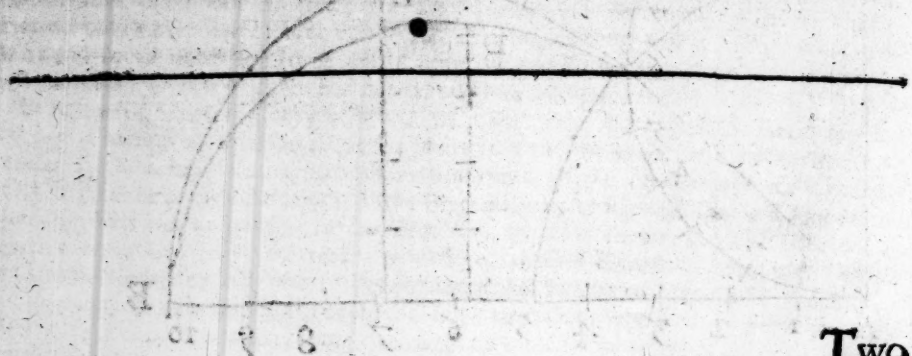
And hence he concludes that the dead or exact Horizontal Shot or range, that is in the figure, R λ I to be in Proportion to the middle range as 1 to 6; or in leſſer Guns, as one to five; which dead Horizontal ranges is to the range of an Elevationof one degree, as five to ſix, or more exactly as 55 to 67, or as 14 to 17.

But when the recoyling of the greater Gun is hindred, the dead Horizontal range will be greater by a ſeventh, eighth, ninth, or tenth part, than that range which is made with recoyling; in leſſer Guns it will be a twelfth or a fifteenth part leſs.

Moreover he aſſerts that the middle range A 6 E does proceed righton without arching by the line A G, which may be almoſt equal to A 5, that is, almoſt 5 fold or $4\frac{1}{2}$ the Horizontal ſhot: then not only that it does aſcend to the point D, ſo that the greateſt height of the middle range may be fourfold the Horizontal, and be over the line A C ſixfold the ſame which ſome affirm; but he by obſervation ſaies is falſe againſt *Tartaglia*; affirming that the greateſt altitude muſt be F E, anſwering the point 7, that is ſeven diſtances of Horizontal range from the gun A, that F E may be almoſt five fold the Horizontal range.

Galeus did likewiſe well conjecture that the Curve for the middle range does come near to the Curve of an hyperbolical or parabolical line, and that not by force of reaſon, but only from obſervations. Moreover the greateſt range at forty five degrees elevation he makes 16200 foot, that is 2700 of the *French* fathoms; who becauſe he uſed feet leſs than ours, you might account it for 2500 fathoms, that the ſaid range may anſwer to our league, and that the bullet might paſs through the air in near half a minute, or 30 ſeconds of time: and becauſe the dead Horizontal range may be $\frac{1}{6}$ of the utmoſt, it will be 2700 foot or 450 fathoms, which being ſuppoſed the Horizontal range will ſcarce exceed 200 fathoms.

Merſennus in this place hath publiſhed a table of ranges made by the ſaid *Galeus*, but it being apprehended that the ſame is not ſo near the truth as that of *Torricellio*, or another here publiſhed in *Engliſh* by the antient well known Teacher of the Mathematicks Mr. *Henry Bond*; that the ſame may be preſerved and become more common in uſe we have inſerted the ſame.



Two Tables of
RANGES
According to Degrees of *MOUNTURE.*

By H. Bond.

The first Table.

deg		deg	
1	8758	47	2113
2	7813	48	2150
3	7077	49	2189
4	6482	50	2230
5	5991	51	2272
6	5581	52	2317
7	5234	53	2363
8	4932	54	2412
9	4669	55	2463
10	4440	56	2516
11	4237	57	2572
12	4055	58	2633
13	3889	59	2695
14	3741	60	2762
15	3606	61	2832
16	3483	62	2908
17	3370	63	2989
18	3266	64	3075
19	3279	65	3168
20	3080	66	3268
21	2996	67	3376
22	2978	68	3493
23	2845	69	3621
24	2776	70	3762
25	2712	71	3916
26	2651	72	4086
27	2593	73	4276
28	2538	74	4489
29	2486	75	4732
30	2437	76	5006
31	2391	77	5303
32	2344	78	5690
33	2300	79	6263
34	2260	80	6641
35	2221	81	7274
36	2183	82	8059
37	2146	83	9061
38	2111	84	10430
39	2077	85	12330
40	2044	86	15140
41	2012	87	19850
42	1981	88	29250
43	1952	89	37480
44	2007	90	00000
45	2041		
46	2076		Finis.

The Second Table.

deg		deg	
1	1.142	47	4.736
2	1.280	48	4.653
3	1.413	49	4.570
4	1.543	50	4.487
5	1.669	51	4.403
6	1.792	52	4.318
7	1.911	53	4.234
8	2.028	54	4.148
9	2.142	55	3.062
10	2.253	56	3.976
11	2.361	57	3.889
12	2.467	58	3.800
13	2.572	59	3.712
14	2.674	60	3.622
15	2.774	61	3.532
16	2.872	62	3.440
17	2.968	63	3.347
18	3.063	64	3.253
19	3.156	65	3.158
20	3.248	66	3.061
21	3.339	67	2.963
22	3.428	68	2.864
23	3.516	69	2.762
24	3.603	70	2.659
25	3.689	71	2.554
26	3.774	72	2.448
27	3.858	73	2.339
28	3.941	74	2.228
29	4.024	75	2.114
30	4.105	76	1.998
31	4.186	77	1.880
32	4.267	78	1.758
33	4.347	79	1.634
34	4.426	80	1.506
35	4.505	81	1.375
36	4.584	82	1.241
37	4.662	83	1.102
38	4.740	84	0.960
39	4.818	85	0.812
40	4.895	86	0.661
41	4.972	87	0.504
42	5.050	88	0.342
43	5.127	89	0.174
44	4.985	90	0.000
45	4.902		
46	4.819		Finis.

The use of the first Table, by Example.

1. Suppose a peece curry a shot 763. paces at 13. degrees of *Mounture*, What is the Horizontal Range? Multiply the Number against 13. degrees, which is 3889. by 763. and from the product cut off 2 figures towards the right hand, leaves the paces of the Horizontal Range desired.

The use of the second Table, by Example.

2. Suppose a peece Curry a shot 374 paces at the Horizontal Range; How many paces shall it Curry at 16. degrees *Mounture?* Multiply the Number against 16. degrees, which is 2. 872 of this second Table, by 374. and from the product cut off 3. figures towards the right hand, leaves the Number of paces desired.

3. Having the paces of any degree of *Mounture* to find how far that shall curry a shot at a greater degree of *Mounture*. Example.

Suppose a peece Curry a shot 543 paces at 11. degrees *Mounture*; How may paces shall it curry at 19. degrees *Mounture* ? First multiply the Number against 11. in the first Table, which is 4237, by 543. and Multiply that product again by the Number found in the second Table against 19. degrees, which is 3. 156. And from the Last product cut off 7. figures towards the right hand, and the remainder are the Number of paces desired.

1. By the peeces *Mounture*, and the paces she curries a shot at that *Mounture*, to know how many she curries at level Range, by the direction aforesaid.

2. Having the level Range of a peece, to find how many paces that shall curry at a *Mounture* given, by the directions aforesaid.

3889	2.872
763	374
11667	11488
23334	20104
27223	8616
296(7307	1074(128

3. Having the paces that a peece Curries at one *Mounture*, to find how many paces it should curry at a greater *Mounture*, by the directions aforesaid.

4237	2300691
543	3.156
12711	13804146
16948	11503455
21185	2300691
2300691	6902073
	726(0980796

Two Tables of

RANGES

According to Degrees of MOUNTURE.

By H. Bond.

The Ranges of Spouts or Squirts compared with the Ranges of Bullets ſhot out of Guns.

FOr as much as a Bullet ſpends a greater time in its fall than its riſe, like darts; or the deſcent is not ſo ſwift, that it ſhould always haſten in that degree whereby in three or four ſeconds, we have found its ſwiftneſs to be increaſed, which I ſuppoſe to be confirmed from this reaſon, becauſe a bullet deſcending cannot have ſo great a power to ſmite, as it hath aſcending, ſo that approaching the Earth it is not ſo ſwiftly moved, as when it comes from the mouth of the Gun, for when the ſwiftneſs of any thing projected is equall, it equally ſtrikes.

Therefore I account Spouts uſeful, ſeeing they bring us to the knowledg of ſhooting, of which otherwiſe we could not judge, by reaſon of the difficulty of trial which is moſt eaſily diſcerned in tubes: for becauſe any one may compare in a little time what ever ſhot he pleaſes with another, to wit, a middle Range with a vertical, or Perpendicular one as to time and height, that this may be the better underſtood, in the following figure let the Cock be A above the Horizon A B, and let the altitude of the tube be A 12, whoſe vertical Squirt is A φ; Experience teacheth us that the length of the middle Squirt A B, is double to the Vertical A φ. *Former Figure.*

But to what height the middle Squirt ranges, whether to D or E, which alſo you may underſtand of Bullets ſhot from Guns, there is none hitherto hath obſerved: but it is one half of the vertical φ A, wherefore the point D or E is higher than it ought to be, and whatever is ſaid by the ingenious, may be corrected by ſpouts.

There are other things alſo that want inquiry into; for example, how it can come to paſs, that a bullet ſhot out of the mouth of a Gun from O to P comes right on, when in that time it flying along the line O P a hundred fathoms ought to fall towards the center of the Earth 12 foot, if the horizontal motion of a thing violently projected hinders not its natural motion, as many imagine in a vacuity or place that does not impede.

For although that can partly be explained by the diverſity of the lines, which is found in Guns, to wit the line R X Y, which follows the outſide of the Gun, and that which they call *Linea animæ* S Z, which paſſes thorough the axis of the hollow M N to the aforeſaid ſide, is in no wiſe parallel: becauſe, to wit, the bullet K or H levelling at L may aſcend to the ſide line I L, or the point S paſſing to Z may aſcend to the point X of the ſide line R Y: yet another thing is to be added, when what is aforeſaid is not true, when the eye of the ſhooter takes not aim by the line I L or R X but by the line M N or S X: for then the bullet K does not deſcend ſo much, as it would if it were left to it ſelf in the air.

Add, that the water out of the Cock fitted to the Horizontal Squirt doth not deſcend ſo much, as it would if left to it ſelf; for it is manifeſt by Experience, that the Horizontal Squirt of 30 foot, which continues two ſeconds, deſcends not ſo much as eight foot, when according to the law of bodies of equal weight, it ſhould be 48, or at leaſt by reaſon of the reſiſtance of the air breaking the water it ought to deſcend 30 foot.

FINIS.